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U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN NO. 17.

THE CHINCH BUG:

A GENERAL SUMMARY OF ITS HISTORY, HABITS, ENEMIES, AND OF THE REMEDIES AND PREVENTIVES TO BE USED AGAINST IT.

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LETTER OF SUBMITTAL.

U. S. Department of Agricultur
Division of Entomology,
Washington, D. C., January 3, 1888.

Sir: I have the honor to submit for publication Bulletin No. 17 from this Division, being a paper upon the Chinch Bug prepared by my first assistant, Mr. L. O. Howard, for the forthcoming Annual Report. There are several important, or what the late Dr. LeBaron called "first class," injurious insects, like the Chinch Bug, which I have so far not cared to treat of in the publications of the Division, because in past years, while State Entomologist of Missouri, I had occasion to publish pretty fully upon them and because there is little opportunity to make further investigations or experiments upon them in the vicinity of Washington. I have, however, endeavored to keep a record of everything published in reference to them and of the advance in our knowledge of improved means of controlling them. On account of the great interest felt just now in the Ch inch Bug and the prospect of injury from it the coming summer in the Mississippi Valley, and from the fact that the principal work to be done in preventing such injury is winter work, I have decided, with your approval, to issue this paper in advance as a bulletin, in order to supply the constant demand for information upon the insect at the present time. It may be looked upon as an emergency bulletin published because of the probable delay in the appearance of the more bulky annual report beyond the time when the information will be useful for the coming season.

Respectfully,

C. V. Riley,
Entomologist.

Hon. Norman J. Colman,
Commissioner of Agriculture.

THE CHINCH BUG.

(*Blissus leucopterus*, Say.)

Order HEMIPTERA; family LYGÆIDÆ.

INTRODUCTORY.

The present treatment of the Chinch Bug offers little scope for anything new or original. It is an extremely destructive species which has been exhaustively treated by former writers and which, after several years of comparative scarcity, has again become very injurious, so much so as to occasion the loss of millions of dollars during the past season and to call forth the greatest variety of comment from the press of the country, agricultural or otherwise. In this emergency it happens that there are no public documents for distribution and even no books which can be purchased which treat of the life history of and remedies for this pest. The State reports of Riley and LeBaron are out of print; the small edition of Bulletin 5 of the U. S. Entomological Commission, by Dr. Thomas, was long since exhausted; and the recent bulletin and circular by Forbes treat almost solely of remedies.

It becomes necessary, therefore, to bring out once more a complete review of the subject. Previous writings, particularly those of Riley, are freely used, and in many instances the well-known Missouri reports of my chief are quoted at length.

Observations by Prof. Herbert Osborn, F. M. Webster, W. B. Alwood, and Miss Mary Murtfeldt, Agents of the Division, are acknowledged as they are used. Indebtedness to Prof. G. F. Atkinson, of Chapel Hill, N. C., for observations made in his vicinity, is here acknowledged. The note-books of the Division of Entomology and the extensive records for many years collected by Professor Riley have been at my disposal.

PAST HISTORY.

It has been quite generally accepted that the Chinch Bug is, comparatively speaking, a Southern rather than a Northern insect, and in so far as the matter of destructive appearances goes, this idea is well upheld by its past history. In our section upon geographical distribution, however, we have shown that the species is by no means confined to the more Southern States, but that it is often found north of the

boundary line, in Canada. It was first noticed, so far as we can find, in North Carolina, at the close of the Revolutionary war, where, as has been so often stated, it was mistaken for the Hessian fly, which at that time was attracting considerable notice on Long Island and thereabouts.

Dr. Fitch, in his second report, gives with some little detail an account of its early appearances, from which we may simply state that after this first notice the insect did considerable damage for several years in North Carolina, South Carolina, and Virginia. After a short series of seasons it was again destructive in North Carolina in 1809, so that in Orange County the cultivation of wheat was abandoned for two years.

In 1839, in the same States, great damage was done to corn and wheat, and in 1840 an increase in number occurred, and the wholesale destruction of the crops was only prevented by an exceedingly wet season.

The first scientific description of this species was given by Say in 1831, in a pamphlet, now very scarce, published at New Harmony, Ind., entitled "Descriptions of new species of Heteropterous Hemiptera," from a single specimen collected on the eastern shore of Virginia, and it was probably at that time rare in Indiana, where Say resided, at New Harmony.

It attracted much attention in 1840 in Illinois when it occurred in numbers in Hancock County, where it was supposed to have been introduced by the Mormons, and was called in consequence the "Mormon louse."

According to Professor Riley, the first recorded appearance of the insect in Missouri was in 1839. It was again noticed in 1844, and has been destructive at intervals ever since. In Iowa its first recorded appearance is in 1847, in Indiana in 1854, and in Wisconsin in 1855.

Eighteen hundred and sixty-four was a year marked by damage in these Western States. In 1868, a season of great drought, much damage was done by the bugs in Missouri.

In 1871 great damage was done in Illinois, southern Iowa, in parts of Indiana, in Nebraska, in southern Missouri, and Kansas. It was estimated by Dr. LeBaron in his second Illinois report that the loss to the wheat, oat, and barley crops during this year amounted to $10,500,000 in Illinois alone, and in the other six States mentioned, including Indiana, the total loss was upwards of $30,000,000.

In 1874 they occurred again in Missouri and the adjoining States in exceptional abundance. It was during this season that Professor Riley sent out circulars to all parts of Missouri and at the close of which he wrote the extended article which was published in his Seventh Report on the Insects of Missouri.

He estimated that the total loss to the group of States of which eastern Kansas forms a center was double that of 1871. Very careful estimates by counties gave an aggregate loss of $19,000,000 for

Missouri alone, including only the three staple crops of Wheat, Corn, and Oats. He mentions several facts which tend to show that this estimate is low rather than high. In this report Professor Riley also gave the first accurate and extended descriptions of the adolescent stages, including the egg, and noticed the differences between the number of joints in the tarsi in the young and the adult.

From 1874 to 1881 there were no serious irruptions of this pest, but in this year it attracted considerable notice and did a great deal of damage in some Western States. Much newspaper literature concerning the insect was published during this year, much of which was excited by Thomas's paper upon the "Relation of Meteorological Conditions to Insect Development and Particularly to the Chinch Bug." It was during this year also that the "Chinch Bug convention" was held at Windsor, Kans., and it was decided to exclude Wheat from cultivation as a means of extirpating the pest.

In 1882 the work of the bug upon timothy grass was discovered in Saint Lawrence County, N. Y., for the first time in its history. It increased and spread in 1883, exciting great alarm, and occasioned several articles from the pen of Dr. Lintner, who also issued a circular on remedies and anticipating further damage.

Professor Riley in Science (Vol. II, p. 620) and in his Report for 1884 stated that there was little cause for alarm in New York, and indeed no particular damage has since been recorded. In 1885 some damage was done in parts of Kansas and Nebraska, and in 1886 still more. Bulletin No. 13 of the Division of Entomology contains reports of considerable damage in the spring of 1886 from Kansas, Indiana, Ohio, and Nebraska and more especially in southern Illinois.

During the past year (1887) the injury was marked in these States and also in some parts of Missouri, but the interesting point in the history of this season has been the occurrence of the insect in immense numbers in portions of Virginia and North and South Carolina for the first time in many years. As a thorough review of the localities and damage this season is desirable, a statement has been drawn up at my request by Mr. J. R. Dodge, the statistician of this Department, which is submitted herewith.

Mr. Dodge reports as follows:

In accordance with your request, I take pleasure in communicating the results of inquiries made relative to the geographical distribution of Chinch Bugs during the past season, and to the extent of their destruction of growing crops.

I find indications of their presence throughout the southern and western States, but no material injuries to crops are reported except in States bordering on the Mississippi River and the Lower Missouri. Kansas, part of Nebraska, Missouri, Iowa, Illinois, southern Wisconsin, and eastern Minnesota include practically the field of their serious operations.

They attacked wheat and rye first, then barley and oats, and afterward corn, grass, millet, sorghum, and broom-corn. As corn, wheat, and oats are the principal tilled crops of this area, they represent the principal part of the damage.

In many places the fields were cleared, and small grain areas were ploughed up. The pest came in some cases to districts that had never before been ravaged; in many others the scourge was claimed to be more sweeping than ever before.

The insect was present in injurious numbers in nearly every county in Kansas. Correspondents in Leavenworth, in the extreme east, and Hamilton, on the Colorado border, gave the only negative replies. The worst damage was done in this State.

The infliction was general in Missouri, except in a belt in the central part of the State, not very regular nor wholly untouched, trending northeasterly, and connecting with a similar belt in Illinois.

Further north, no portion of Iowa was exempt, except the northwest corner of the State, in proximity to areas of exemption from central Minnesota westwardly through Dakota, and near to a similar area in northern Nebraska. In eastern Minnesota and southern Wisconsin, however, the scourge was general and severe. In Illinois comparative exemption was enjoyed in a central belt running in a northeasterly direction from Christian to Champaign, and from Adams to Bureau, fifteen to twenty counties, in which correspondents responded in the negative as to their destructive presence. Elsewhere the pest was nearly universal.

The southwestern corner of Indiana was alive with Chinch Bugs; elsewhere, though present in much of the area, only about a dozen counties estimated any material losses. They were still scarcer in Michigan. Only ten counties in Ohio reported their injurious presence; and a few only in Kentucky indicated material damage.

These insects are reported as more or less injurious in every season of drought and scarce or absent in all wet areas. In the area of their depredations the crops have an annual value of more than a fourth of the entire agricultural production of the United States, and a value nearly four times as great as that of the cotton crop. It will readily be seen that the losses must be heavy, undoubtedly greater than those of all other insects together, as no such values are involved in other crops subject to insect depredations the past year.

The following table has been prepared from data, severely scrutinized, revised, and accurately consolidated. It makes a large sum, and yet does not comprise all the damage done to barley and rye, millet, etc., all of which might be approximately stated in round numbers as $60,000,000. The record by States is as follows:

States.	Corn.		Wheat.		Oats.	
	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.
Kentucky	983, 280	$521, 138	66, 678	$48, 675	.....	.....
Ohio	885, 564	425, 071	215, 370	161, 528	60, 196	$19, 263
Indiana	1, 785, 000	803, 250	453, 936	326, 834	167, 658	48, 621
Illinois	16, 929, 600	6, 941, 136	5, 529, 150	3, 870, 405	3, 810, 310	1, 028, 784
Wisconsin	1, 804, 250	757, 785	3, 004, 490	1, 922, 874	1, 742, 750	487, 970
Minnesota	2, 169, 720	802, 796	9, 074, 750	5, 354, 103	2, 438, 160	633, 922
Iowa	22, 020, 240	7, 707, 084	6, 977, 620	4, 256, 348	4, 462, 920	1, 071, 101
Missouri	15, 504, 390	5, 736, 624	1, 664, 640	1, 032, 077	795, 860	206, 924
Kansas	16, 840, 340	6, 230, 926	2, 282, 100	1, 392, 081	6, 406, 560	2, 438, 497
Total	78, 922, 384	29, 925, 810	29, 268, 734	18, 364, 925	19, 884, 414	5, 935, 082

Respectfully,

J. R. DODGE,
Statistician.

Accompanying these statements of Mr. Dodge were a number of State maps indicating the counties reporting to the Department damage from the Chinch Bug. Many other localities had Chinch Bugs in abundance and considerable damage was done in States not represented in

this list. These localities, however, are authoritative, and their reports furnished the main basis for the table which precedes. We may summarize these briefly as follows:

Illinois, fifty-one counties, as follows: Stephenson, Winnebago, Lake, Carroll, Lee, Kendall, Will, La Salle, Rock, Mercer, Warren, Stark, Iroquois, Vermillion, Edgar, Douglas, Coles, Moultrie, Shelby, Cumberland, Clark, Jasper, Effingham, Fayette, Bond, Madison, Macoupin, Greene, Pike, Jersey, Saint Clair, Clinton, Washington, Marion, Clay, Lawrence, Wabash, Edwards, White, Hamilton, Franklin, Randolph, Jackson, Williamson, Saline, Gallatin, Johnson, Pope, Hardin, Massac, and Alexander.

Indiana, twenty-five counties, as follows: Elkhart, Jasper, White, Huntington, Wells, Blackford, Jay, Warren, Montgomery, Wayne, Shelby, Johnson, Sullivan, Greene, Dearborn, Knox, Martin, Ohio, Gibson, Pike, Dubois, Posey, Vanderburgh, Warrick, and Spencer.

Iowa, sixty-one counties, as follows: Winnebago, Worth, Mitchell, Howard, Winneshick, Allamakee, Clayton, Fayette, Chickasaw, Floyd, Cerro Gordo, Hancock, Palo Alto, Pocahontas, Humboldt, Franklin, Dubuque, Buchanan, Grundy, Hamilton, Webster, Calhoun, Sac, Crawford, Carroll, Greene, Story, Marshall, Tama, Benton, Linn, Jackson, Clinton, Scott, Muscatine, Iowa, Jasper, Dallas, Guthrie, Audubon, Shelby, Madison, Mahaska, Keokuk, Des Moines, Henry, Monroe, Lucas, Union, Adams, Montgomery, Mills, Fremont, Page, Taylor, Decatur, Wayne, Appanoose, Davis, Van Buren, Lee.

Kansas, sixty-three counties, as follows: Cheyenne, Rawlins, Norton, Phillips, Jewell, Washington, Marshall, Nemaha, Brown, Wyandotte, Jefferson, Jackson, Shawnee, Douglas, Pottawatomie, Riley, Wabaunsee, Davis, Clay, Cloud, Mitchell, Rooks, Graham, Sheridan, Thomas, Sherman, Gove, Russell, Lincoln, Ottawa, Ellsworth, Saline, Dickinson, Morris, Osage, Franklin, Miami, Linn, Anderson, Coffey, Chase, Marion, McPherson, Rice, Barton, Rush, Ness, Lane, Scott, Ford, Pawnee, Stafford, Reno, Sedgwick, Allen, Neosho, Cherokee, Labette, Chatauqua, Cowley, Sumner, Barbour, Comanche.

Kentucky, eight counties, as follows: Carroll, Pendleton, Bracken, Estill, Mercer, Union, Ballard, Marshall.

Michigan, five counties, as follows: Manitou, Presque Isle, Saginaw, Shiawassee, Saint Joseph.

Minnesota, twenty-seven counties, as follows: Hubbard, Wadena, Todd, Crow Wing, Kanabec, Pine, Isanti, Chisago, Sherburne, Stearns, Wright, Carver, Scott, Rice, Wabasha, Winona, Olmstead, Dodge, Steele, Waseca, Watonwan, Martin, Faribault, Freeborn, Mower, Fillmore, and Houston.

Missouri, sixty counties, as follows: Atchison, Nodaway, Holt, Worth, Gentry, Harrison, Mercer, Putnam, Sullivan, Adair, Linn, Clinton, Caldwell, Ray, Chariton, Randolph, Lincoln, Saint Charles, Callaway, Copper, Johnson, Cass, Bates, Henry, Saint Clair, Hickory, Osage, Maries, Gasconade, Franklin, Jefferson, Washington, Sainte Genevieve, Perry, Iron, Bollinger, Cape Girardeau, Mississippi, New Madrid, Butler, Wayne, Oregon, Shannon, Pulaski, Laclede, Wright, Douglas, Ozark, Christian, Webster, Dallas, Hickory, Polk, Cedar, Dade, Barton, Lawrence, Barry, Newton, and McDonald.

Ohio, ten counties, as follows: Defiance, Wood, Geauga, Allen, Shelby, Darke, Franklin, Fairfield, Meigs, and Gallia.

GEOGRAPHICAL DISTRIBUTION.

East of the Rocky Mountains the Chinch Bug seems to be indigenous North and South, feeding naturally upon various species of wild grasses and becoming multiplied wherever the cultivation of wheat has reached its original haunts.

It was first noticed, as stated in the last section, in North Carolina, and Say's original description was published from a Virginia specimen.

Fitch records the fact that he had collected specimens in New York, but that it was exceedingly rare. Signoret also records it from New York, and, as we have just shown, it appeared in 1883 in destructive numbers in the northern part of this State. Harris in the first edition of his well-known work states that it does not occur in New England, but in a foot-note to his second edition states that while the sheet was passing through the press he discovered a single specimen in his own garden at Cambridge (June 17, 1852). And in 1883, according to Dr. George Dimmock (Psyche, November, December, 1883, p. 119), the lowland between Belmont and Cambridge was swarming with them. They have also been collected by Dr. Packard at Salem, Mass., in Maine, and at the summit of Mount Washington in New Hampshire. Dr. Lintner records the fact that Mr. H. L. Fernald captured one or more specimens in 1879, 1880, and 1882, at Orono, Me.

In Canada they occurred at Grimsby, Ontario, in 1866, and were sent from that point in that year to Mr. Walsh. Mr. W. H. Harrington collected specimens found abundantly at Sydney, Cape Breton (N. lat. 46° 18′) in September, 1884 (Can. Ent., November, 1884, p. 218). Dr. Fitch received specimens from western Pennsylvania, and also stated that it was sent him from Mississippi with the information that in some years it damaged the crops of Indian corn. We have found it personally in considerable numbers in the rice fields near Savannah, Ga., and Mr. E. A. Schwarz and others have collected it in Florida. In the latter State Mr. Schwarz found it very abundantly at Biscayne Bay, breeding in the wingless form only in considerable numbers upon Sand Oats (*Uniola paniculata*). Mr. Webster has noticed it in Mississippi and Louisiana. It has also been collected in this same form, upon the same plant, on the sea-shore at Fortress Monroe, Va., by Messrs. Schwarz and Heidemann. The States, however, in which it does the greatest damage are Virginia, North Carolina, South Carolina, Ohio, Indiana, Kentucky, Tennessee, Illinois, southern Wisconsin, Iowa, Missouri, Kansas, and Nebraska. Uhler records the species from Texas, California, Kansas, Nebraska, Wisconsin, Minnesota, Illinois, Michigan, and generally throughout the Atlantic region.

Outside of the United States it is recorded only from Cuba (see Signoret "Essai Monographique du Genre Micropus, Spinola;" Ann. Soc. Ent. France, V, 3d series, 1857, p. 31), and the Cuban individuals are long-winged, while Mr. Schwarz never found a long-winged individual in Florida, in spite of the fact that he has collected in localities the insect fauna of which is in the main Cuban. This observation conflicts with the general observation of Mr. Uhler that the short-winged form seems to be more common in New England than in the Southern States.

The only authentic published record of the occurrence of the Chinch Bug west of the Rocky Mountains is the mere mention by Uhler, in his list of

the Hemiptera of the region west of the Mississippi River (Bull. Hayden Surv. I, 306), of California as one of the States which it inhabits, but this record has been overlooked by Californians. Its advent upon the Pacific slope has been expected and dreaded. Matthew Cooke in his book, published in 1883, upon injurious insects of the Orchard, Vineyard, etc., figured and described it, and under the head of "Remedies" wrote, "Should the pest appear in this State it can be prevented," etc.

In June, 1885, there were several newspaper reports on the occurrence of this insect in great numbers in California. The San Francisco Evening Post for June 23, 1885, quoting from the Woodland Democrat, published the statement:

> Messrs. Frazee and Henderson, who live southwest of Woodland, brought to this office a bottle of this pestiferous insect (chinch bug) on Tuesday. Mr. Henderson says that he recognized them as the same eastern variety that frequently does so much injury to wheat in Missouri. These gentlemen say they discovered the bugs traveling between the lands of Day and Clanton. There are millions of them, but as to the extent of country covered they are unable to say. The bugs are nearly grown and are just beginning to have wings. As soon as the wings develop they fly and scatter everywhere. Mr. Frazee says there is no danger from them this year as the grain is too far advanced.

So far this item seems very plausible, but it goes on to state "that another gentleman had noticed them injuring grape-vines" which of course introduces a probability of wrong identification.

There is no question, however, but that the Chinch Bug is to be found at present in California, but there is no assurance of its existence in injurious numbers. Our certainty as to its presence arises from the fact that a single specimen of a short-winged variety of this insect is among a lot collected in the vicinity of San Francisco in 1885 by Mr. Koebele. It is unquestionably a true Chinch Bug. Another specimen of the same variety was collected in 1884 by some students of Johns Hopkins University who summered in California and was given to Mr. Lugger, of this Division, who was at that time connected with the University. Recent communications from California in answer to inquiries on this point show that the insect is not known to the entomologists in that State. The False Chinch Bug (*Nysius angustatus*) has been, we learn from Mr. Koebele, very destructive to grapes in that State the past season, and it is more than likely that this is the insect referred to in the newspaper article just quoted. Mr. Koebele writes that the False Chinch was so abundant around Alameda in July that in an old road at least 50 specimens could be counted under each plant of *Polygonum aviculare*. He made, in 1887, a most careful search of the locality in which he found the 1885 specimen, but could not find a single additional individual. He also examined the large collection of Hemiptera in the California Academy of Sciences without success. The following paragraph is from Mr. Coquillett's answer to our inquiries:

> I have never met with the Chinch Bug in any part of California that I have visited—neither in Merced County, around the city of Sacramento, nor on the southern part of

the State, where I have collected Hemiptera extensively with the sweep-net. Dr. Rivers, curator of the museum at our State University, writes me that three years ago he took three specimens of a bug that looked much like the Chinch Bug, but was darker and smaller, and he does not believe that they belonged to this species; they were taken in Sonoma County, and were sent off, he knows not where. He has collected Hemiptera extensively since then, but the Chinch Bug is not among them. Mr. Wickson, editor of the Pacific Rural Press, writes me that he has "never seen a specimen nor heard of one as being recognized by an observer whom I would consider as capable of recognizing the insect."

Since writing the above we have learned from Mr. Uhler that he has seen specimens of the Chinch Bug from California of a long-winged form, which were collected near San Francisco, probably by Mr. Henry Edwards. He has also seen specimens from Cuba and from Tamaulipas, Mexico.

FOOD PLANTS.

The Chinch Bug will feed upon all grains and grasses so far as known. The most prominent crops which are seriously injured are Wheat, Barley, and Indian Corn. The testimony in regard to Oats is conflicting, but Le Baron's conclusion to the effect that "if this grain be sown where Chinch Bugs abound, and especially if it is sown exclusively, it will be damaged to a greater or less extent the first year, but that the bugs will probably not continue to breed in it to any great extent in succeeding years" is unquestionably correct. Broom-corn, Sorghum, Chicken-corn, Hungarian grass, Millet, Rye, Rice, Bermuda grass (*Cynodon dactylon*), Fox-tail grass (*Setaria glauca*), Timothy (*Phloeum pratense*), Blue-grass (*Poa pratensis*), Crab-grass (*Panicum sanguinale*), Bottle-grass (*Setaria viridis*), and all of our wild grasses, so far as known, are attacked, but beyond these no food plant has ever been authentically recorded. Reports of damage done to other crops, such as grape-vines and garden crops, are the result of mistaken identity, and an error in the compilation of Packard's Guide to the Study of Insects has doubtless done much to perpetuate the idea that this insect is a more general feeder. This was corrected in the later editions of this work, probably at the suggestion in Professor Riley's criticism in his 7th Rept. Ins. Mo., p. 26.

Upon the Sand Oats (*Uniola paniculata*) in Florida Mr. Schwarz noticed that the entire development of the insect is undergone upon the highest part of this tall plant and not close to the bottom as in our latitude. The probable reason for this, as he has pointed out, is, that the strong winds are continually blowing fine, sharp sand through the lower parts of the plants, rendering it impossible for the bugs to remain at these places and forcing them to seek their nourishment higher up.

Concerning Timothy and the Crab-grasses Professor Forbes says:

> It seems to prefer timothy to blue grass, not really relishing either as a general thing, and takes to the crab-grasses (*Panicum*) not at all, or only as a last resort. (Bull. No. 2, State Ent. Ill.)

This generalization is undoubtedly correct for Illinois and the surrounding States, but, as Professor Forbes himself points out in a foot-

note, the bugs did great damage to Timothy in northern New York in 1883, and the following extract from a letter recently received from Professor Atkinson, of North Carolina, indicates that in that State at least the Crab-grass becomes an important item of the insect's diet.

* * * I have recently discovered that at this season of the year (October 2) the chinch bug feeds on the "crab-grass" so common in cultivated and waste places, and especially so abundant in many of the corn-fields after cultivation has ceased. The chinch bug must go to grass after the corn becomes mature and no longer yields the sap. I have found the bugs inside the sheath and clear evidence of their having punctured the culm. No doubt this grass affords them subsistence for quite a period of time and then shelter for the winter. * * * I have found within the past few days pupæ or wingless individuals on the crab-grass. * * *

Referring again to Timothy we may state that a meadow of this grass on the farm of J. F. Whiton, near Wakeman, Huron County, Ohio, was injured considerably by the bugs in 1886. Professor Forbes, however (Bull. 2), gives an instance where sowing Timothy with Fall Wheat was probabably the cause of the salvation of the crop.

On cultivated Rice we found Chinch Bugs very generally scattered throughout the large rice-fields near Savannah, Ga., in August, 1881. Only adult specimens were found at that time and all were fully winged, and were found upon the heads of the grain, to which they had probably flown, as the fields had been flooded for some time previously. No particular damage to the crop was perceptible, unless their punctures contribute to bring about the disease known as "white blast," as suggested by Pr ofessor Riley in his Annual Report for 1881–'82, page 137.

We shall probably be obliged to widen our close restriction of the Chinch Bug food plants, to admit at least one of the Polygonums. A chance statement by Mr. Bruner that he had known this insect to feed upon the so-called "Wild Buckwheat" in Nebraska led to a letter of close inquiry, to which he replied that there can be no mistake and that the plant is either *Polygonum dumetorum*, or *P. convolvulus.*

STAGES OF GROWTH—DESCRIPTIVE.

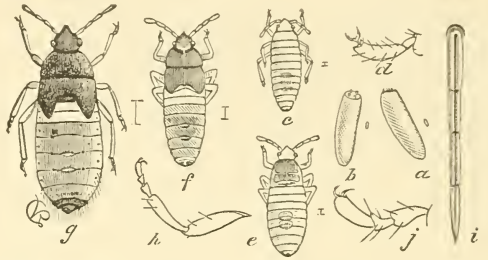
The following descriptive matter is from Professor Riley's Seventh Report on the Insects of Missouri, and is fuller and more careful than that published elsewhere. It will be noticed that there are three larval stages, necessitating two molts before the pupa and three before the adult. It will also be noticed that the larvæ have but two joints to the feet, while the adults have three:

The Egg.—(Fig. 1*a*, *b*.) Average length 0.03 inch, elongate oval, the diameter scarcely one-fifth the length. The top squarely docked, and surmounted with four small rounded tubercles near the center. Color when newly laid, pale and whitish and translucent, acquiring with age an amber color, and finally showing the red parts of the embryo, and especially the eyes toward the tubercled end. The size increases somewhat after deposition, and will sometimes reach near 0.04 in length.

Larval Stages.—The newly-hatched larva (Fig. 1*c*) is pale yellow, with simply an orange stain on the middle of the three larger abdominal joints. The form scarcely

differs from that of the mature bug, being but slightly more elongate; but the tarsi have but two joints (Fig. 4*d*), and the head is relatively broader and more rounded, while the joints of body are sub-equal, the prothoracic joint being but slightly longer than any of the rest. The red color soon pervades the whole body, except the first two abdominal joints, which remain yellowish, and the members, which remain pale. *After the first molt* (Fig. 1*e*) the red is quite bright vermilion, contrasting strongly with the pale band across the middle of the body, the prothoracic joint is relatively longer, and the metathoracic relatively shorter. The head and prothorax are dusky and coriaceous, and two broad marks on mesothorax, two smaller ones on metathorax, two on the fourth and fifth abdominal sutures, and one at tip of abdomen are generally visible, but sometimes obsolete; the third and fourth joints of antennæ are dusky, but the legs still pale. *After the second molt* (Fig. 1*f*) the head and thorax are quite dusky, and the abdomen duller red, but the pale transverse band is still distinct; the wing-pads become apparent, the members are more dusky, there is a dark red shade on the fourth and fifth abdominal joints, and, ventrally, a distinct circular dusky spot covering the last three joints.

FIG. 1.



IMMATURE STAGES OF CHINCH BUG.—*a*, *b*, eggs; *c*, newly-hatched larva; *d*, its tarsus; *e*, larva after first molt; *f*, same after second molt; *g*, pupa—the natural sizes indicated at sides; *h*, enlarged leg of perfect bug; *j*, tarsus of same still more enlarged; *i*, proboscis or beak, enlarged.—[After Riley.]

Pupa.—(Fig. 1, *g*.) In the pupa the coriaceous parts are brown-black, the wing-pads extend almost across the two pale abdominal joints which are now more dingy, while the general color of the abdomen is dingy gray; the body above is slightly pubescent, the members are colored as in the mature bug; the three-jointed tarsus is foreshadowed, and the dark horny spots at tip of abdomen, both above and below, are larger.

[FIG. 2.]

CHINCH BUG: Hair line underneath showing natural size. [After Riley.]

Imago.—(Fig. 2.) The perfect insect has been well described and I will append the original description:

Lygaeus leucopterus (Chinch Bug). Blackish; hemelytra white, with a black spot.

Inhabits Virginia.

Body long, blackish, with numerous hairs. Antennæ, rather short hairs; second joint yellowish, longer than the third; ultimate joint rather longer than the second, thickest; thorax tinged cinereous before, with the basal edge piceous; hemelytra white, with a blackish oval spot on the lateral middle; rostrum and feet honey yellow; thighs a little dilated.

Length less than three-twentieths of an inch.

I took a single specimen on the eastern shore of Virginia.

The whiteness of the hemelytra, in which is a blackish spot strongly contrasted distinguishes this species readily (Say, Am. Entomology, I, p. 329).

The above description originally appeared in 1832 in a pamphlet entitled "Descriptions of new species of Heteropterous Hemiptera of N. A."

Length 1⅞ lines, of three-twentieths of an inch. Body black, clothed with a very fine grayish down, not distinctly visible to the naked eye; basal joint of the antennæ honey yellow; second joint of the same tipped with black; third and fourth joints, black; beak brown; wings and wing-cases white; the latter are black at their insertion, and have near the middle two short irregular black lines, and a conspicuous black marginal spot; legs dark honey yellow, terminal joint of the feet, and the claws black. (Dr. Wm. LeBaron in the Prairie Farmer for September, 1850, Vol. X, pp. 280, 281, where the name of *Rhyparochromus devastator* is proposed for it.)

Dr. Fitch also enumerates the following varieties of this insect:

a, immarginatus.—Basal margin of the thorax not edged with yellowish. Common.

b, dimidiatus.—Basal half of the thorax deep velvety black, anterior half grayish. Comm on.

c, fulvivenosus.—The stripes on the wing-covers tawny yellow instead of black.

d, albivenosus.—Wing-covers white, without any black marks except the marginal spot. A male.

e, apterus.—Wingless and the wing-covers much shorter than the abdomen. (Fig. 3.)

f, basalis.—Basal joint of the antennæ dusky and darker than the second.

g, nigricornis.—Two first joints of the antennæ blackish.

h, femoratus.—Legs pale livid yellow, the thighs tawny red. Common.

i, rufipedis.—Legs dark tawny red or reddish brown.

To these varieties, all of which occur with us, I would add one which may be known as *melanosus*, in which the normal white of the wings is quite dusky, and contains additional black marks at base and toward tip, and in which all the members and the body except the rufous hind edge of thorax are jet black.

[FIG. 3.]

SHORT-WINGED CHINCH BUG. [After Riley.]

In addition to these varieties mentioned by Dr. Riley, an interesting form has been collected by Mr. E. A. Schwarz at Lake Worth, Fla., and by Mr. O. Heidemann at Fortress Monroe, Va. This variety is at once distinguished from other short-winged varieties by its more slender and pointed wing-pads, and by the color of the antennæ, the first three joints of which are honey yellow, while the last joint or club is nearly black. It seems also to be more thickly clothed with silvery pile, but this is probably due to the fact that the specimens studied were mounted dry, while all others which I have seen have evidently been placed in alcohol. This variety, so far as we know, has been collected on the sea-shore only.

NUMBER OF BROODS AND HIBERNATION.

For many years there existed a misconception concerning the number of broods of insects in the West. It was always understood that there was more than one brood, and some newspaper writers insisted that there are as many as five or six annual generations. Professor Riley, in the Practical Entomologist, Vol. I (March 26, 1866), was first to publish the definite statement that the Chinch Bug is two-brooded in northern Illinois, and Dr. Shimer the succeeding year published the same state-

ment from his own observations. This number of annual generations holds through the entire northwest and as far south, certainly, as the latitude of Saint Louis. Thomas states that there is some evidence of an occasional third brood in the extreme southern part of Illinois and in Kentucky, but that it is not sufficient to justify him in stating it as a fact, or to satisfy him of its correctness. In North Carolina there seems no question but that the second generation gave birth to still a third, which, as we are informed by Professor Atkinson of Chapel Hill, was found in a half-grown condition on Crab-grass about the 1st of October. November 17 most of the specimens found in the same locations were full-grown. This third generation probably hibernates in the adult condition.

The Chinch Bug passes the winter in the perfect state. As cold weather approaches, most of the full-grown bugs leave the hardened corn-stalks or wild grasses upon which they have been attempting to feed, and seek some convenient shelter in which to pass the winter. They collect in fence cracks, in sheds, hay stacks, straw stacks, corn-shucks, under leaves, mulching, and rubbish of all kinds upon the ground, under the loose bark of adjacent trees, in stumps and logs, under stones and clods of earth, in fact in any situation which will offer shelter. They seem to prefer dry situations. Bunches of old dead grass and weeds offer them a particularly attractive place for hibernation. Professor Atkinson writes us that the Crab-grass in North Carolina not only affords the bugs sustenance after the corn-stalks harden, but also gives them shelter for the winter, as they work their way down between the leaf-sheath and the stalk. Mr. J. O. Alwood writes us from Columbus, Ohio, that, October 26, 1887, he observed them lying torpid within the leaf-sheaths of an uncut field of Pearl Millet. During cold weather they remain torpid. On a warm, sunshiny day they will stretch their legs and begin to move about to a slight extent; but as the cold becomes severe they press back deeper into their hiding places. They can withstand the severest cold, and in fact, as with so many other hibernating insects, the more sustained the cold weather the more the insects winter successfully. An instance is related by a reliable correspondent of Dr. Thomas' in which the bugs frozen into ice were thawed and when warm manifested signs of life, crawling about as in the spring. Dr. Shimer's observations upon this point are sufficiently interesting to quote:

> After the early autumn frosts they left their feeding-grounds on foot in search of winter quarters; none could be seen on the wing as at harvest time. For a winter retreat they resorted to any convenient shelter they might chance to find, as long grass, weeds, boards, pieces of wood, rails, fallen-tree leaves, etc.
>
> In January, 1865, I next examined their condition. Those that I found in the sheaths of the corn-leaves above the snow, and had been thus exposed during the previous severe weather—when for several days the thermometer was 15° to 20° below zero—were invariably found dead without exception, and those beneath the snow

were alive. This observation was made in the common farm corn-fields, as they might be found anywhere all over the wide country, for in autumn the chinch bugs remained in great numbers in the corn-husks and under the sheaths of the blades as well as in other winter retreats. Upon various occasions, as the winter advanced, I brought in corn-husks filled with ice, inclosing the chinch bugs in the crystallized element; when the ice was thawed they were able to run, apparently unaffected by that degree of cold. It is therefore proved that these insects possess vitality sufficient to withstand the effect of a temperature below the freezing-point, and perhaps below zero, as must have been their condition in these ice-bound husks; but when in the open air, exposed to the sweeping prairie winds, 15° to 20° degrees below zero, for a long time, they succumb to the cold.

March 7, 1865, the snow having cleared off from the ground, I examined the condition of a host of these chinch bugs that had chosen for their winter covering cord-wood sticks lying on the ground, entirely surrounded by frost and ice; of these 20 per cent. were living; those that were more fortunate in their selection of winter quarters fared much better. From a single handful of leaves picked up at one grasp from beneath an apple tree I obtained 335 living and 312 dead chinch bugs; and of their lady-bird enemies that had entered the same winter quarters with them, 50 were living and 10 dead. Of these chinch bugs I placed a number in comfortable quarters in the house in a small pasteboard box, not in a stove room, together with some coleopterous insects casually gathered among the chinch bugs; after one month I found the latter all dead and the former living.

The entire month of March was rain, snow, thawing, freezing, alternately, seeming to be very uncomfortable for any living creature to remain out of doors with so poor a shelter and on top of the ground.

April 1–6, I again made repeated examinations of these chinch bugs in their winter quarters, and found about the same proportions of them living as noted on the 7th of March. At this time they wandered away on foot from their winter quarters.

Mr. G. A. Waters, in the Farmers' Review for October 19, 1887, gives the following interesting observation bearing on the same point:

In 1881–'82 I observed a bunch of fodder that had fallen into a ditch that the heavy rains had washed near by a shock. The fodder had been overflowed with water, which had stood over the fodder long enough for a sheet of ice to form over it. The water subsiding in a few days and some thaw occurring, I pulled the stalks out of the mud to get the ears of corn off, and in husking the ears found quite a number of chinch bugs which had been immersed for a week or more. On exposing them to the warm sun they crawled around lively.

Where they are hibernating in numbers they can often be detected more readily by their strong "bed-buggy" odor than by sight, as was pointed out by Dr. Riley. Dr. Lintner, in October, 1883, found this method of searching for them more convenient and infallible than looking for them.

Mr. Bruner calls our attention to the fact that the Osage and other brushy hedges in the West are great collectors of leaves and trash blown there by winds, and that they form exceptionally good hibernating places for the Chinch Bugs, which take advantage of them in great numbers. So great a nuisance are the hedges from this point of view, that Mr. Bruner seriously advocates their gradual removal and the substitution of a less compact division between fields.

HABITS.

With the warm days of spring the hibernating individuals issue from their winter quarters and copulate. Dr. Shimer has described a love-flight which he noticed at this time. The date was May 16, 1865, and the atmosphere was swarming with Chinch Bugs on the wing. As shown by Walsh and Riley (Am. Ent., I, 173) it is probable that this occurrence was exceptional, and that the insects do not normally mate in this way; that the swarming flight was the result of a great abundance of the insects. The insect flies in spring and fall, and also somewhat in late July and early August, as the first brood becomes winged. In the fall they attain wings as the corn hardens, and their flight is then the result of a starvation impulse. In July and August the flight of the fledged individuals of the first brood is not very common, except when they occur in exceptionally great numbers. During the past season Professor Osborn observed them coupling at Ames prior to July 25, while upon this date he observed them swarming in the air, flying past his window in immense numbers and with the wind (southeast to northwest). They were first noticed shortly after 1 p. m. July 27 they were again noticed on the wing, but not in such great numbers as before. They were flying with the wind, from northwest to southeast. August 3 hosts of them were observed on the wing, while others were coupling on the ground. Others were observed coupling as late as August 16. The majority of the hibernating individuals seem, from the evidence, to copulate in the spring and without flying, but, according to Professor Riley, many of them make love in the fall preparatory to seeking winter quarters, and Mr. James O. Alwood, of Columbus, Ohio, writes that he found them copulating in a field of uncut Pearl Millet at the Ohio Agricultural Experiment Station as late as October 27, 1887.

The eggs of the Chinch Bug, which we have already described, and which are figured at Fig. 1, *a*, *b*, are laid in the spring for the first brood, and usually underground and upon the roots of plants infested. They are, however, often found above ground upon the withered sheaths near the bases of the grain stalks or often upon the blades of the leaves. They are deposited in small clusters. Professor Riley says:

> A wheat plant pulled from an infested field in the spring of the year will generally reveal hundreds of these eggs attached to the roots, and at a somewhat later period the young larvæ will be found clustering on the same and looking like so many moving atoms.

The eggs are not specially small when we consider the small size of the female which lays them. Dr. Shimer says that each female lays 500, and this seems very large until we reflect that they are not all deposited at once, and that after the laying of the first few others are probably developing in the ovaries, for the process of oviposition occupies from ten days to three weeks. It has long been known that the eggs were laid in the ground, although an accurate description was much more recently

drawn up. The relative abundance of the eggs upon the stalks and upon the roots may be changed somewhat, as Dr. Thomas has pointed out, by the character of the soil. Where the soil is very damp the majority of the eggs are doubtless laid upon the stalks, whereas if the earth is dry and easily penetrated the great majority of them will be found upon the rootlets and upon the stalks beneath the ground. According to Professor Riley the eggs hatch on the average in two weeks. The young larvæ begin to take nourishment as soon as possible after hatching. They insert their beaks sometimes even before they emerge from the earth, but more often crawl up the stalk before beginning to pump. They growl with considerable rapidity and swarm over the stalk upon which they were born, walking about with ease and wandering from one stalk to another if occasion demands. As we have already shown, four molts are undergone before the insect reaches the perfect state, and generally from five to seven weeks elapse from the hatching to the final molt. Dr. Shimer's repeated observations show that at Mount Carroll, Ill., the imago usually appears in from fifty-seven to sixty days after the laying of the eggs, and about forty-two days from the hatching of the larvæ. By the time the majority of the insects of this first generation are full-grown, or even before, the wheat has become too hard to offer them much nourishment, or harvest time has arrived, and they begin to migrate in search of food. Neighboring cornfields offer a more tempting diet, and in seasons of great abundance they march in numerous colonies, moving by a common impulse from the wheat to the corn. Strange to say, although the commoner form possesses wings the insect does not generally take flight, but prefers to walk along the ground. Occasionally, however, at this time they take wings and scatter. This, however, is rarer when the insects are plentiful than when they are comparatively scarce. Under no circumstances will these insects take flight to escape danger. Dr. Shimer says:

> No threatening danger, however imminent, whether of being driven over by grain-reapers, wagons, or of being trodden under foot, will prompt it to use its wings to escape. I have tried all imaginable ways to induce them to fly, as by thrashing among them with bundles of rods or grass, by gathering them up and letting them fall from a height, etc., but they invariably refused entirely to use their wings in escaping from danger.

The migration takes place often, and, according to some authors, usually before the majority of the brood have attained full growth. There are always many immature individuals among a large host, and often the army is composed almost entirely of such. In fact, at these times there is apt to be a general confusion of so-called larvæ, pupæ, and adults, owing to the fact that some hibernating females oviposit much in advance of others and to the other fact, previously mentioned, that a single female takes several days or even weeks to lay all of her eggs. Professor Forbes records egg-laying presumably by hibernating individuals from the last week in May (at Decatur) until the last week in June (at Warsaw), thus making certain individuals of the first brood one

month later in development than others, in two localities not far distant (140 miles) and of about the same latitude. There are many accounts in print which are almost incredible tales of the size of these migrating hordes, and yet they are probably only too true.

Dr. Thomas states that the migration upon foot seldom exceeds 80 rods, but the winged individuals fly to much greater distances. Instance was given in the Farmers' Review for August 17, 1887, where a little patch of sweet corn grown in the midst of pine woods in northern Wisconsin, 8 miles from a cultivated crop of any kind, was badly infested with the Chinch Bug. This appearance of the bugs probably resulted from the flight thereto of mature individuals.

It naturally results from the wide difference in the method of growth of the crops that the Chinch Bugs after migrating from wheat to corn appear to be much more numerous upon the latter crop than they were upon the former, in spite of the great numbers usually killed in the act of migrating; for a single stalk of corn will be obliged to support the Chinch Bugs from a great many stalks of wheat. Moreover, the bugs swarm upon the first few rows and destroy them before invading the entire field generally. The outer rows, of course, under these circumstances are often black with bugs. The pupæ work their way down between the leaves and the stalks and there cast their skins and issue as adult insects. The leaf sheath is often thus completely filled with exuviæ. The eggs for the second brood are also often if not usually deposited in this same situation—behind the sheaths of the lower leaves—and on hatching the young bugs remain there feeding and growing, and casting skins, sometimes even until the advent of cold weather and their consequent winter torpor. Others issue from these sheaths, particularly when they are especially abundant, or failing to find satisfactory locations on the outer rows take wings and fly to the center of the field and become generally scattered. They feed upon the Corn or Rye as the case may be, and upon the surrounding grasses or in the fields of Millet or Hungarian grass until the approach of fall, by which time nearly all are once more full-grown. Mr. Webster observed them at Lafayette, Ind., in August, 1887, forcing themselves down into cut stubble of *Setaria glauca* for the purpose of undergoing the last molt. He counted upwards of twenty in a single stalk. We may mention in this connection, as reported to us by Prof Osborn and also as published in the Country Gentleman for August 25, 1877, that President Chamberlain, of the Iowa Agricultural College, dug a single root of Hungarian grass at Ames, Iowa, the first week in August upon which were counted 3,025 bugs. Earth was removed with the root to the depth of 3 inches (1 inch surface), in all about 4 cubic inches.

In the north the majority of them are ready to hibernate by the time the field corn is harvested. Farther south, however, the corn grows too hard for them and considerable time before the weather is cold enough to compel them to seek winter shelter. In North Carolina, as

we have already shown, a third brood has appeared by the time the corn becomes hard, and the bugs seek the Crab-grass and there feed until ready for hibernation, finding in this grass, moreover, good shelter for the winter.

The general statements here given apply to the average Chinch Bug year in Illinois, Missouri, and the surrounding States, as the articles from which we have drawn our main facts are the results of observations made in these States. The life-history and habits of the species undoubtedly differ considerably in the more southern States, where, however, it seldom does much damage. It is very doubtful, however, that the habits differ so greatly as to admit of the correctness of the statement quoted by Fitch from the Southern Planter (XV, 269), that the eggs are laid in the ground in autumn where they remain through the winter and until the warmth of the ground the following year causes them to hatch! This great error (at least for the West and North) is unfortunately perpetuated by Dr. Lintner in his second report as State entomologist of New York, p. 153. There seems, in fact, every reason to suppose that this was simply a guess on the part of the editor of the Southern Planter without the slightest observation to substantiate it. At our request, Professor Atkinson examined a number of females found near Chapel Hill, N. C., in November, but found no evidence of mature eggs. He also searched carefully for deposited eggs with, of course, negative results. He states that Mr. Thomas S. Weaver, of Chapel Hill, has observed the bugs for the past ten years and states that they never oviposit in autumn.

In exceptional seasons and under exceptional conditions the life-history and habits will vary considerably even in the localities referred to; for example, in 1882, according to Professor Forbes's first Illinois report, there was evidently in some parts of the State but one brood, and the first young bugs were not seen before July 10. The eggs of the first brood were in some localities this season laid upon corn.

NATURAL ENEMIES AND DISEASES.

INSECT ENEMIES.—No true internal insect parasites of the Chinch Bug have yet been found. In fact very few of these smaller Heteroptera are parasitized except in the egg state. The minute Proctotrupidæ belonging to *Teleas* and *Telenomus* infest the eggs of allied species and may ultimately be found to attack the eggs of the Chinch Bug. Outside of these genera, however, we can hardly expect any aid from parasitic insects. In this connection, although it does not strictly come under this head, we may mention that in 1885 Mr. Webster found a species of *Mermis* ("hair-snakes") among the dried moltings and dead bodies of certain Chinch Bugs in a stalk of *Setaria*, which gives rise to a strong probability that one of these creatures will be found to infest the bug. Many predaceous insects destroy them, although their disgusting odor is probably more or less a protection.

Mr. Walsh in 1861 mentioned four Ladybirds, viz, the Spotted Ladybird (*Hippodamia maculata*, Fig. 4), the Trim Ladybird (*Coccinella munda*, now called *Cycloneda sanguinea*, Fig. 5), and two species of *Scymnus*. In

[Fig. 4.]

SPOTTED LADYBIRD.

[Fig. 5.]

TRIM LADYBIRD.

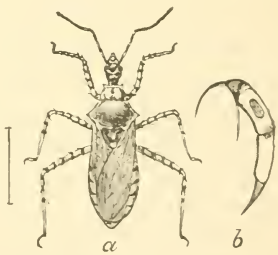
1882 Prof. Forbes found five species of Ladybirds (including the first two mentioned by Walsh) extremely abundant on corn (15 or 20 to a hill) which was infested by hosts of Chinch Bugs. The contents of the stomachs of a few specimens of each were examined with the following results: In three specimens of *Hippodamia maculata* no traces of Chinch Bugs were found, the food consisting of the spores of lichens, the pollen of Rag-weed, and traces of Plant-lice. One-third of the food of *Hippodamia convergens* (5 specimens examined) consisted of equal parts of Chinch Bugs and Plant-lice. In 4 specimens of *Hippodamia glacialis* 8 per cent. of the food was found to be Chinch Bugs, 18 per cent. Plant-lice, and the rest vegetation. A single specimen of *Coccinella 9-notata* had eaten no insect food. Three specimens of *Cycloneda sanguinea* had eaten some Plant-lice, but no Chinch Bugs. From these observations Professor Forbes concludes that it is possible that the Ladybirds were attracted "rather by the stores of fungi in the field than by the Chinch Bugs and Plant-lice."

The Weeping Lace-winged Fly (*Chrysopa plorabunda*, Fitch) described originally by Dr. Shimer as *Chr. Illinoiensis*, has been found by Dr. Shimer to destroy the Chinch Bug. Professor Riley records the fact that the Insidious Flower Bug (*Triphleps insidiosus*, Say., Fig. 6), an insect

[Fig. 6.]

INSIDIOUS FLOWER-BUG. [After Riley.]

[Fig. 7.]



MANY-BANDED ROBBER. [After Riley.]

which is often found in company with the Chinch Bug and which has been mistaken for it, in reality feeds upon the pest. This is the insect which was sent to Dr. Fitch as a Chinch Bug, and which he described as *Anthocoris pseudochinche* in his second report. Professor Riley also

records the fact that he has observed the Many-banded Robber (*Milyas cinctus*, Fab., Fig. 7) in the act of preying upon the Chinch Bug, and Dr. Thomas considers this insect the most efficient of the insect enemies of the pest.

Two of Professor Riley's correspondents in 1874 stated that ants destroyed the eggs of the Chinch Bug, but the observation lacks scientific confirmation. Professor Forbes in 1882 observed a small ant (*Lasius flavus*) in extraordinary numbers in fields of Broom-corn and Sorghum, and both he and the farmer, whom he does not mention by name, made each an independent observation upon an ant which was carrying off a Chinch Bug in its jaws, but repeated dissections of ants found in such fields failed to show that they had fed on the bugs.

Professor Forbes in his 1882 report adds to the list of observed insect-enemies a common Ground-beetle—*Agonoderus pallipes* (*Comma*) Fabr.—of which, upon dissection, one-fifth of the total food was found to be Chinch Bugs. This is the insect figured upon Plate 1 of Bulletin 12 of the Division of Entomology and which is there stated to destroy seed corn in the ground, so that its beneficial qualities are offset by its injurious tendencies.

The evidence of Dr. Shimer, Dr. Walsh, and others, is quite sufficient to establish the fact that the Lady-birds and the Lace-winged Fly mentioned will feed upon the Chinch Bug, and Dr. Shimer's evidence in favor of the latter insect is particularly strong. His testimony as to the great abundance of the Lady-birds upon corn infested by Chinch Bugs is of course only presumptive evidence of their good work in destroying this insect. It is unquestionable, however, that the Lady-birds prefer Plant-lice to the Chinch Bugs; and in at least one instance which has been reported to us, when the Lady-birds were present upon corn in considerable numbers, and when this crop was infested by the Chinch Bug, a careful study by the observer (Mr. Lawrence Bruner) showed that the Corn Aphis was also present, and that the Lady-birds were feeding upon these latter, and did not, so far as he could see, touch the Chinch Bugs. Professor Forbes' stomach examinations previously mentioned also tend to cast discredit upon the Lady-birds as Chinch Bug destroyers.

VERTEBRATE ENEMIES.—Professor Riley published many years ago in the Prairie Farmer the fact that the common Quail, or Bob White (*Colinus virginianus*), was a most efficient destroyer of the Chinch Bug, and this fact has since been confirmed by other writers. Dr. Riley says:

> In the winter time when hard pushed for food they must devour enormous numbers of the little pests which winter in just such situations as are frequented by the quail, and this bird should be protected from the gun of the sportsman in every State where the Chinch Bug is known to run riot.

We may add the corroborative evidence of Mr. Bruner, who combines the knowledge of an entomologist with that of an ornithologist:

> Protect the birds, and above all the quails, for they destroy countless numbers of hibernating insects of various kinds that are to be picked up about the hedges and such like resorts frequented by these birds throughout the winter. Although be-

longing to the gramnivorous birds the quail is essentially insectivorous, except in inclement weather, when insects are not easily obtained. In my profession as taxidermist I have dissected many different species of birds in the crops of which were contained injurious insects of various kinds—the chinch bug among others. In no other instance do I remember of the presence of this insect in the crop of a bird in so great numbers as in that of the quail. As a rule but few birds, mammals, reptiles, or rapacious insects seem to relish any of the odoriferous members of the Hemiptera or true bugs. In winter, however, this repugnance is partially overcome, and now and then even a chinch bug seems a delicate morsel when "meat" is scarce.

The Prairie Chicken, the Red-winged Black-bird, and other birds have been reported as feeding upon the Chinch Bug, and Professor Forbes mentions the fact that one Cat-bird, three Brown Thrushes, and one Meadow Lark were found in 1880 to have eaten these insects "in barely sufficient number to show that the birds have no unconquerable prejudice against them. A single House-wren, shot in 1882, had also eaten a few Chinch Bugs." Dr. Thomas states that the common frog, according to Professor Ross and others, consumes a large number of the bugs:

Professor Ross goes so far as to express the belief that the destruction of these animals by draining their natural haunts is one reason why the chinch bug is enabled to multiply as it does in some seasons.

No account of an injurious insect is complete without an enumeration of its natural enemies and hence this summary has been given. It is plain, however, that the foes of the Chinch Bug are neither so numerous nor so active in its pursuit as are those of most injurious insects. Almost the solitary exception seems from the evidence to be the common Quail, and on this account the following short table has been compiled. It illustrates the months in which the shooting of quails is allowed in the States in which the Chinch Bug becomes or may become injurious, and it shows that while these birds are in the main tolerably well protected, certain of the States which suffer most from the Chinch Bug might with profit follow the example of Colorado or Dakota and protect the Quail altogether for a series of years.

New York.—Shooting of quails allowed from November 1 to January 1.

Maryland.—Shooting of quails allowed from November 1 to December 24. There are, however, in this State, local county laws, some of which allow the shooting as early as October 1.

Virginia.—Shooting of quails allowed west of the Blue Ridge October 15 to January 1, except in Rockbridge County, where it is allowed from October 15 to January 15; elsewhere October 15 to January 15.

Texas.—Shooting of quails allowed from October 1 to April 1.

Georgia.—Shooting of quails allowed from October 15 to April 1.

Wisconsin.—Shooting of quails allowed from November 1 to December 1. Trapping prohibited.

Michigan.—Shooting of quails allowed from November 1 to January 1. No trapping or snaring allowed for market.

Pennsylvania.—Shooting of quails allowed from October 15 to January 1.

Tennessee.—Shooting of quails allowed from October 1 to April 1 in Rutherford, Shelby, Tipton, and Fayette Counties; September 1 to February 1, in Robertson, Davidson, Lincoln, and Maury Counties; September 15 to March 1, in Montgomery and Cheatham Counties.

Missouri.—Shooting of quails allowed from October 15 to February 1. Trapping prohibited except by owner of premises.

Delaware.—Shooting of quails allowed from November 15 to January 1.

North Carolina.—Shooting of quails allowed from October 15 to April 1, except in counties of Clay, Cherokee, Graham, Henderson, Jackson, Macon, Transylvania, Tyrrell, Johnston, Jones, Ware, Onslow, Carteret, and Columbus, in which they are not protected. In Currituck County, December 1 to April 1.

Iowa.—Shooting of quails allowed from October 1 to January 1. No more than twenty-five quails to be killed in any one day by any one person.

Dakota.—Quails protected absolutely to 1890.

Illinois.—Shooting of quails allowed from November 1 to January 1. Snaring and trapping forbidden.

Ohio.—Shooting of quails allowed from November 10 to January 1. Snaring and trapping forbidden. In Fulton County quails protected to November 1, 1890.

Nebraska.—Shooting of quails allowed from October 1 to January 1. Snaring and trapping forbidden.

Indiana.—Shooting of quails allowed from October 15 to December 20.

Minnesota.—Shooting of quails allowed from September 1 to December 1. Trapping prohibited.

District of Columbia.—Shooting of quails allowed from November 1 to February 1. Trapping prohibited.

South Carolina.—Shooting of quails allowed from October 1 to March 15.

Montana.—Shooting of quails allowed from August 15 to November 15.

Arkansas.—Shooting of quails allowed from October 1 to March 1.

Colorado.—Quails protected at all times.

West Virginia.—Shooting of quails allowed from October 15 to January 1. Snaring prohibited.

Kentucky.—Shooting of quails allowed from October 15 to February 1.

Idaho.—Quails protected until September 1, 1887. (Present status of law unknown.)

New Mexico.—Shooting of quails allowed from September 1 to May 1.

Kansas.—Shooting of quails allowed from November 1 to January 1.

This compilation is drawn up in the main from an extended abstract of the State laws, published in the American Field for August 20, 1887, Vol. XXVIII, No. 8.

DISEASES.—The Chinch Bug has long been known to be subject to a so-called bacterial disease, which occasionally kills it off. Dr. Shimer,

in his long article in the Proceedings of the Academy of Natural Sciences of Philadelphia, gives the following account of his observations upon this disease in 1865. (Proceedings of the Academy of Natural Sciences of Philadelphia for 1867.)

July 16.—A farmer four miles from here informed me that a black coleopterous insect was destroying the chinch bugs on his farm very rapidly, and, although I found his supposition to be an error, yet I found many dying on the low creek-bottom land from the effects of some disease, while they are yet in the larvæ state—a remarkable and rare phenomenon for insects thus in such a wholesale manner to be dying without attaining their maturity, and no insect enemy or other efficient cause to be observed capable of producing this important result. * * *

On the low grounds the young chinch bugs are all dead from the disease above alluded to, and the same disease is spreading rapidly on the hills and high prairies.

The weather has been very wet since the first of July, and the barley above alluded to, which I plowed beneath the ground, did not die, but assumed a yellow, sickly appearance; in its shady, compressed, unnatural position, the ends of the heads project from beneath the furrows. The chinch bugs also remained alive for a time, but feeding on the sickly grain and shaded from the sunlight—what little we had—were attacked by disease in the same manner and about the same time as those on the low creek-bottom lands, meeting very rapidly the same fate, so that very few of them ever found their way to the neighboring corn.

July 28.—In the fields where sixty days ago I saw plenty of eggs, and forty-two days ago an abundance of young chinch bugs, the imago are beginning to develop quite plentifully. Great numbers, in all stages of their development, are dying of the prevailing disease.

August 8.—The majority of the chinch bugs yet alive are in the imago state, but they are being rapidly destroyed by the prevailing epidemic disease, more fatal to them than the plague of Asiatic cholera ever was to man, more fatal than any recorded disease among men or animals since time began. Scarcely one in a thousand of the vast hosts of young bugs observed at the middle of June yet remain alive, but plenty of dead ones may be seen everywhere, lying on the ground, covered with the common mold of decomposing animal matter, and nothing else, even when examined by the microscope. Even of those that migrated to corn-fields a few weeks ago, in such numbers as to cover the lower half of the corn-stalks, very few are to be found remaining alive; but the ground around the base of the corn-hills is almost literally covered with their moldering, decomposing dead bodies. This is a matter so common as to be observed and often spoken of by farmers. They are dead everywhere, not lying on the ground alone, but sticking to the blades and stalks of corn in great numbers, in all stages of their development, larva, pupa, and imago.

August 22.—It is almost impossible to find even a few cabinet specimens of chinch bugs alive, so that I am quite sorry that I did not secure a large supply of specimens while they were so numerous in former years; for it really appears quite probable that even cabinet specimens will be hard to secure, whereby to remember the fallen race of the unnumbered millions of former years.

September 13.—After a whole day's searching in the corn-fields, I have just been able to find two larvæ and a few imago chinch bugs, against the great numbers above alluded to in the corn about this time last year.

* * * * * * *

It is generally believed among entomologists that insect enemies are the most efficient means in nature for exterminating noxious insects; but in this remarkable fact in the history of insects, the great epidemic of 1865 (there can be no doubt about this being an epidemic disease, because the insects died without attaining their maturity), we find a greater enemy, the greatest insect enemy ever recorded, a dreadful "plague," that in a few days almost utterly annihilated a race of beings living in the

northern part of the valley of the Mississippi, outnumbering all the human beings that have ever lived on this planet since the morning of creation.

This disease among the chinch bugs was associated with the long-continued wet, cloudy, cold weather that prevailed during a greater portion of the period of their development, and doubtless was in a measure produced by deficient light, heat, and electricity, combined with excessive humidity of the atmosphere, whereby an imperfect physical ("bug") organization was developed. The disease was at its maximum during the moist weather that followed the cold rains of June and the first part of July. The young chinch bug spent a great portion of its time on or near the ground, where its body was colder than the atmosphere; hence, upon philosophical principles, there must have been an excessive precipitation of watery vapor in the bronchial tubes. These are the facts in the case, but in the midst of the great obscurity that envelops epidemic diseases among men, it would be only idle speculation to attempt to define the cause more definitely than the physiological laws already observed seem to indicate. At all events it will require many years of warm, dry summers, and accompanying winters of plenty of snow for protection, to reinstate the lost innumerable armies of this insect.

During the summer of 1866 the chinch bugs were very scarce in all the early spring, and up to near the harvest I was not able, with the most diligent search, to find one. At harvest I did succeed in finding a few in some localities.

Professor Forbes took up the study of the Chinch Bug Disease in August, 1882, and has published several interesting accounts of his results. A short summary was published in his first report as State Entomologist of Illinois, for the year 1882, of the long account of his studies and experiments, and it is in such shape that we reproduce it here:

On the other hand, a much more important rôle is apparently played by certain obscure parasites, not previously detected. One of these is a minute bacterium (*Micrococcus insectorum*, Burrill), infesting the alimentary canal, closely allied to the *micrococcus* found in the stomach and intestines of silk-worms, and now known to cause some of the destructive diseases of that insect. From the fact that these parasites were extremely abundant in specimens from a field where the bugs were rapidly dying, while in those from adjacent fields there were relatively very few, it was considered probable that they were related to this destruction of the bugs. This conclusion was supported by the fact that they were more abundant in old bugs than in young, while the mortality referred to evidently also chiefly affected the older individuals. It was found easy to cultivate the bacterium artificially in organic infusions, but no opportunity offered to apply it to healthy insects. Until this experiment is made and the effects carefully studied, it must remain *possible* that the coincidence noted was merely accidental, and of no particular significance.

Another parasite discovered is similar to that well known as a common enemy of the house fly, and belongs to the same genus (*Entomophthora*). This attacks both old and young chinch bugs, and finally embeds their bodies in a mass of mold. There is some reason to believe that this was the active agent in an immense destruction of chinch bugs which occurred in Northern Illinois in 1866, as described by Dr. Shimer, of Mount Carroll. Evidence is adduced of the possibility of artificially cultivating this parasite also, and applying it to the destruction of insects.

Since the publication of this report Professor Forbes has taken up the study of bacterial diseases of certain other insects, but there has been, so far as we are aware, no practical outcome as yet. The subject, however, has a rather hopeful look, although we should be inclined to expect more from the *Micrococcus* than from the *Entomophthora*. The evidence mentioned as to the possibility of artificially cultivating the

latter is chiefly a translation of a paper by Metschnikoff in the Zoölogischer Anzeiger for 1880, pp. 44–47 in which it is shown the Russian naturalist successfully induced the growth of the fungus, *Isaria destructor*, which had destroyed the celebrated *Anisoplia Austriaca*, a grain pest in Russia, in beer mash. Successful attempts were made to infest healthy larvæ with green spores taken from diseased larvæ found in the fields, but no mention is made of success, or even of experiment with the only practical substance—the beer-mash culture.

Professor Riley has always doubted the possibility of any practical success in this direction, and has pointed out the difficulties in the way. (See American Naturalist, November, 1883, p. 1170.)

In the introduction to the Fourth Report of the U. S. Entomological Commission (LXXXV) he makes use of the following language:

> In treating of the use of yeast ferment or other fungus germs we have used essentially the language of the first edition. Time has only served to confirm us in our opinion of their practical futility in the field. The question of the practical use of these micro-organisms—these disease germs—as insecticides is a very fascinating one, and is much written about just now; but unfortunately it proves most alluring to those who have had the least practical experience in coping with injurious insects in the field, and is much more apt to assume importance to the closet theorists than to those who, from experience, are conscious of the difficulties involved in its applicability.

It will also be apropos to quote Professor Forbes' latest utterance upon this point. He says:

> Finally, *the artificial cultivation of the germs of the contagious diseases* of the chinch bug, with a view to spreading these diseases at will by means of such artificial culture. This is a theoretical remedy only, and much additional study and experiment will be required to put it on a practical basis.

WET WEATHER AND THE CHINCH BUG.

The great preponderance of evidence favors the idea, now considered well established, that wet weather is inimical to this insect. Dozens, we may almost say hundreds, of instances are on record in which the Chinch Bugs, after successfully hibernating in great numbers, have been rendered harmless by a wet spring, and in which, having laid their eggs and appeared again as the spring brood with greatly increased forces, a spell of rainy weather in early summer has caused them to vanish. Hence, it follows that dry seasons favor the increase of the pest; and careful observation convinced Riley and others that after a season of moderate abundance (presumably therefore not a wet season) the occurrence of the bugs in destructive numbers the next season depends almost entirely upon the wetness or dryness of the ensuing spring.

The exact method in which wet weather accomplishes the destruction of the insect is a somewhat disputed point. That it is not actual submergence was pointed out by Professor Riley in his second Missouri report, and still further proven by an observation made by Hon. William McAdams and reported by Professor Forbes in his first report as

State entomologist of Illinois, and which is sufficiently interesting to quote:

In his vicinity, in Jersey County (Ills.), they (the chinch bugs) were extremely abundant in the grain early in the spring, but were all apparently swept out of the country by a long and violent storm. Some days afterwards, when the water had subsided, he noticed in pulling over the drift-wood in the river bottoms immense numbers of chinch bugs among the rubbish, most of them still alive and crawling about.

Professor Forbes also concludes that simple exposure to moisture hardly has the effect attributed to rain from experiments which he made as follows:

A number of hills infested by the bugs were successfully transplanted to boxes and variously treated with water for ten days. Some selected examples were thoroughly drenched every day, both ground and stalks; in other boxes only the ground was watered; in still others the corn was sprinkled every day, but the ground protected; and the remainder were left with only sufficient attention to keep the corn alive. During the time for which these experiments were continued, no appreciable effect whatever was produced upon the bugs infesting the stalks. Those where the corn was watered were washed down upon the ground each time, but soon dried off and climbed up the stalk. At the end of this time the bugs under observation all commenced to disappear indiscriminately, without reference to the mode in which the corn had been treated, and the experiment was thus abruptly closed. Enough was learned, however, to show that a succession of heavy daily showers for more than a week would have no appreciable effect upon these insects in that stage. The weather was warm and pleasant, and the conditions under which the experiments were carried on made it impossible to saturate the air.

So general a conclusion it seems to us is hardly warrantable from the conditions under which the experiments were made. If "the weather was warm and pleasant, and the condition under which the experiments were carried on made it impossible to saturate the air," the effect could hardly help but differ from that of a heavy shower in a corn-field, particularly from that of "a succession of heavy daily showers for more than a week," when there would be considerable cloudy weather and the atmosphere on the whole would be moist.

Professor Riley mentioned the fact that the larvæ and pupæ are more readily killed by the wet weather than the adult insects, but that the latter are also killed.

Mr. Walsh (Am. Ent. I, 175, 1869) gives the emphasis of italics to the following sentence:

In a hot, dry season chinch bugs are always the worst; in a wet season it is impossible for them to do any considerable amount of damage.

Dr. Shimer (*loc. cit.*), in his account of the epidemic, argued that it was doubtless the indirect effect of the wet weather. Dr. Thomas (Bull. 5, U. S. E. C.) expressed the opinion that the wet weather gave rise to a minute fungus which is the direct cause of the death of the insect. Professor Forbes says:

The phenomena connected with the action of parasites, which I have above described, were apparently independent of any appreciable general cause, as they were most manifest at a time when the weather had been warm, dry, and altogether un-

exceptionable for from one to two months. It is not unlikely, however, that wet weather may have the effect to stimulate the development of this parasite, either directly or indirectly—a hypothesis which will reconcile all the facts now known, as well as the conflicting explanations of them which have been hitherto put forth.

Assuming the dry weather abundance and wet weather scarcity of the Chinch Bug to be proven, Dr. Thomas in 1880 published an elaborate article in which by a comparison of the rain-fall for forty years, with the destructive appearances of the insect for the same period, he not only established a definite relation between them, but upon an admittedly somewhat uncertain septennary periodicity of rain-fall advanced the following practical conclusions:

The first and very important practical fact revealed is that we may expect at most but two chinch bug years in every seven, with the strong probability, amounting almost to a certainty, that there will not be two in succession. As heretofore stated, two successive dry years are necessary in order to develop this species in excessive numbers; the rain-fall records seldom show three dry years in succession, hence the chinch bugs are not likely to appear in injurious numbers in two successive years. The years 1854 and 1855 may, perhaps, form an exception to this rule. It is possible that the second brood of the first year may be sufficient to excite alarm, but experience has shown that they do but little injury. We may, perhaps, with safety assume, as a general rule subject to occasional exceptions, that they will not appear more than once in excessive numbers during any of the septennary periods.

If the facts shown in reference to periodicity in our rain-fall are confirmed by future investigations, and this periodicity shown to be a meteorological law of the area indicated, the practical advantage of this knowledge to our farmers is apparent to every one. By this knowledge they will be enabled to predict with a reasonable degree of certainty when to expect these insects, and can rotate their crops so as to suffer the least possible injury. This knowledge will also enable them to dispense with precautionary measures except in such years as are likely to be followed by the appearance of the bugs.

Experience has shown, and farmers are now becoming fully aware of the fact, that spring wheat and corn are the crops that chiefly aid in sustaining and developing this pest. Why corn should aid in this respect is easily seen, as it is the only extensive crop on which the second brood can feed. But why spring wheat should aid more in developing them than winter wheat is not so easily explained, but that such is the fact must be admitted. It may possibly be accounted for on the presumption that the climate of the spring wheat region is more congenial to them than that of the winter wheat area.

These facts, combined with a knowledge of the time when the dry seasons are to be expected, will enable the farmers to substitute other crops as far as possible in place of spring wheat and corn. Even if the conclusion in reference to periodicity in rain-fall should prove erroneous, the fact that two successive dry years are necessary to develop this species in excessive numbers will suffice to give notice at least one season in advance and allow the farmers to adapt their crops to the circumstances. When a dry season comes and an examination shows that the bugs are on the increase, winter wheat, wherever it is possible to do so, should be substituted for spring wheat; and oats, as far as possible, for corn.

The uncertainty in reference to temperature will, perhaps, always prevent us from predicting with certainty that a coming year will be marked by the appearance of these insects, but we may say with assurance that a wet year will not be followed by a chinch-bug year. Although this is not all we desire to know in this respect, it is, nevertheless, a very important fact and may be used to manifest advantage by our agriculturists.

It is proper to remark at this point that we have been speaking only of the rainfall over the whole area designated and the general appearance of the chinch bug over the same area.

That these insects have appeared even in injurious numbers in limited localities in intermediate years, or times different from those indicated as possible chinch-bug years, is certainly true. But, if the theory advanced is correct when applied to the area designated as a whole, it will probably prove true when applied to more limited localities. That is to say, if the meteorological record of a given locality within this area for a long series of years is examined, it will probably reveal the fact that there is a similar periodicity in the rainfall, though possibly not septennary. If this is found to be true, then the farmers of that locality will have a guide by which to rotate their crops and to take precautionary measures.

It therefore becomes important for each section to keep a record at least of the rainfall, for this will be of advantage, not only in counteracting the chinch bugs, but numerous other species, and if a periodicity is ascertained will enable the farmers to adapt their crops as far as possible to the wet or dry seasons.

In the October (1880) number of the American Entomologist (Vol. III) Dr. Thomas published practically the same article as that above quoted and stated that the bugs would probably appear over the region indicated in 1881. He advised, in consequence, the sowing of large areas of oats in 1881. Prof. Riley, in his Annual Report for 1881–'82 (p. 87), mentioned this prediction and advice, and showed that the prediction was fulfilled in part, at least, by the occurrence of the bugs in destructive numbers in several Western States. With regard to the adoption of Dr. Thomas' advice, however, he pointed out the rather curious fact that Dr. Thomas' own State (Illinois) was the only one of the large oat-producing States in which the acreage of this crop was not increased, but was somewhat diminished. Dr. Thomas in the letter of transmittal to his report for 1881 announced the fulfillment of his prediction and predicted immunity for 1882. Professor Riley (*loc. cit.*) showed that in spite of frequent rains in the spring of 1882, and in spite of the fact that 1881 was a Chinch Bug year, the bugs appeared in great numbers in parts of Illinois, Kansas, and Missouri in April and May, but that by June the reports were less alarming. The year as a whole was not marked by any extensive damage.

Upon Dr. Thomas' theory the year 1888 should not be a Chinch Bug year, and, while not desiring to encroach upon his prerogative as a seer, we are inclined to hold the same opinion concerning this season at least.

Curiously enough, an anonymous writer (J. C. H. S., of Sedgwick County, Kans.) in the Prairie Farmer for June 10, 1882, commenting upon and criticising Dr. Thomas' theory, himself predicts that 1887 would be a year of drought and consequently a Chinch Bug year—a much more daring prediction than Dr. Thomas cared to make, and which has yet been perfectly fulfilled. According to this writer's somewhat arbitrary system, 1894 will again bring a severe drought.

We introduce here, as bearing upon the rain-fall influence in the interesting North Carolina locality, the following table of temperature and

rain-fall at Chapel Hill, compiled by Professor Atkinson. It will be noticed that while the total rain-fall in both 1886 and 1887 was greater than in 1885, that during September, October, and November, 1886, and March and April, 1887, was comparatively slight, and that during June and July, 1887, high temperature occurred with the comparatively heavy rain-fall.

Table of temperature and rain-fall for spring, summer, and autumn, at Chapel Hill, N. C., for the years 1885, 1886, *and* 1887.

[The temperature is expressed in degrees Fahrenheit.]	March.	April.	May.	June.	July.	August.	September.	October.	November.	Totals to October.
1885.										
Highest temperature	75	94	90	94	100	94	92	81	71	.....
Lowest temperature	15	31	40	63	61	57	46	35	27	.....
Mean temperature	42.3	55.3	66.5	74.7	77.3	74.8	68	56.6	52.3	.....
Rain-fall (inches)	3.5	2.71	4.34	1.32	3.95	1.98	6.45	6.27	3.81	24.25
1886.										
Highest temperature	80	93	93	93	98.5	96	94	89	77	.....
Lowest temperature	24	33	46	53	62	55	52	35	24	.....
Mean temperature	49.3	59.6	67.7	78.8	76.9	75.9	75.9	58.6	49.1	.....
Rain-fall (inches)	4.97	5.99	4	6.22	7.48	9.91	2.86	1.47	2.79	41.43
1887.										
Highest temperature	83	91	93	101.8	103	92	98	.....	.....	.....
Lowest temperature	26	28	45	49.7	65.7	52	36	.....	.....	...
Mean temperature	46.9	58.3	70.6	74.7	79.8	74.4	69	.....	.....	
Rain-fall (inches)	3.93	2.56	6.59	6.22	6.11	10.8	1.39	.....	.....	37.60

The following tables are published for comparative purposes. They are kindly furnished by the Chief Signal Officer, and include the official records of precipitation in Chinch Bug States for 1885, 1886, 1887:

Stations.	Precipitation.		
	1885.	1886.	1887.
Maryland:	*Inches.*	*Inches.*	*Inches.*
Baltimore	46.04	52.11	43.59
Virginia:			
Cape Henry	36.55	[1]44.76	.....
Chincoteague	41.85	45.23	[2]19.74
Lynchburgh	46.35	51.85	40.62
Norfolk	43.25	54.33	47.72
North Carolina:			
Charlotte	58.35	64.60	51.26
Hatteras	68.02	54.72	55.07
Kitty Hawk	54.78	[3]53.98	.....
Macon, Fort	62.34	[4]47.50	.....
Smithville (now Southport)	48.07	38.93	59.49
Wilmington	60.42	56.43	51.47
Indiana:			
Greencastle	50.11	[3]31.65	.....
Indianapolis	39.51	39.88	33.08
Ohio:			
Cincinnati	33.94	31.35	35.08
Cleveland	39.93	37.34	35.36
Columbus	42.25	42.39	30.25
Sandusky	54.23	31.00	29.85
Toledo	33.19	32.90	32.01

[1] Closed December 31, 1886.
[2] Closed June 18, 1887.
[3] Closed November 4, 1886.

Stations.	Precipitation.		
	1885.	1886.	Part 1887.
	Inches.	*Inches.*	*Inches.*
Illinois:			
Cairo	31.99	37.98	26.75
Chicago	44.37	26.77	29.13
Springfield	38.61	31.69	25.15
Wisconsin:			
La Crosse	30.70	22.49	17.37
Milwaukee	32.58	31.46	30.46
Minnesota:			
Duluth	19.96	33.37	28.56
Moorehead	22.68	26.76	21.97
Saint Paul	25.33	22.89	25.85
Saint Vincent	16.58	15.04	18.47
Missouri:			
Lamar	[1]47.05	33.48	35.72
Saint Louis	45.59	44.34	35.30
Kansas:			
Concordia	[2]17.11	28.24	25.26
Dodge City	23.71	19.35	15.80
Leavenworth	43.64	22.25	37.05

[1] Ten months' record. [2] Eight months' record.

REMEDIES AND PREVENTIVES.

The remedies and preventives recommended as late as the publication of Professor Riley's 7th Rept. Ins. Mo., and there considered by him are as follows: Irrigation, burning, trapping, trampling, rolling, manuring, early sowing, mixing seed, or protecting one plant by another, preventing the migration from one field to another by upright boards or by plowed furrows or ditches, abstaining from cultivation of grains upon which the insect feeds. These remedies were also treated in detail by Dr. Thomas in Bulletin 5 of the Commission. Since this, although many changes have been rung in the agricultural newspapers on these remedies, very few entirely new ideas have been advanced. We may mention more particularly, before taking up a more detailed consideration of this question, the successful adoption of the kerosene emulsion for application at the time of migration or immediately afterwards.

Preventions.

Clean Cultivation.—With no insect more than the Chinch Bug is there greater necessity for clean cultivation. We have shown already that the insect hibernates under rubbish of all kinds, and that the grass and weeds growing in the fence corners and the leaves which accumulate there are admirable places for these insects to collect and winter. Where corn-stalks are left in the fields, and where rubbish of any kind is allowed to accumulate, there the bugs will surely be found. Therefore, the more thoroughly a field is cleaned up in the fall, the more carefully the fence corners are weeded out, and the more the bare soil is turned under the fewer will be the chances for successful hibernation.

Diversified Farming.—It follows from what we have said concerning food plants of this insect and the crops most attacked, that, from the

Chinch-bug standpoint alone, to say nothing of its other advantages, the more diversified the system of crops the better chance there will be for preventing it. A farmer who plants only Winter Wheat, Corn, and small vegetable patches, as is the practice in so many parts of the West, will always be liable to lose a large share, if not all, of his expected remuneration, from the attacks of this insect. "Diversified farming, with wheat mainly left out," is the editorial recommendation of the Prairie Farmer (September 17, 1887), and is certainly an exemplification of condensed wisdom. The object of the omission of Wheat, particularly Winter Wheat, is, of course, to afford as little food as possible for the first generation. Similarly the plan has been suggested of abstaining from Corn in wheat and other small-grain growing regions, with the purpose of affording as little food as possible for the second brood. The result of this plan will be that after harvest the bugs will make their way to the wild grasses, will disperse more, and vastly fewer will successfully hibernate than if there were the usual superabundant supply of food for the second generation.

Rotation of Crops.—From these same facts it also follows with self-evident clearness that crops attractive to these insects should not be sown year after year upon the same ground. This idea is so plain as to require no elaboration. Abstaining from the cultivation of grain upon which the insect feeds where, in spite of the efforts for protection elsewhere mentioned, the Chinch-bug damage is still great, will, of course, end the difficulty. Wheat, Barley, Rye, Hungarian Grass, and Millet are all important crops, but there are others such as Buckwheat, Clover, Flax, Hemp, all vegetables and fruits which could well be made to take their place for a year or two, or more, if it should become necessary. The one great result of the Chinch-bug convention held in Kansas in 1881 was the adoption of a resolution to abstain from the cultivation of Wheat, the length of time not being mentioned. As we have previously shown, large areas of Oats could be successfully grown, but in corn-growing regions most small grains must be left alone, and above all Winter-wheat and Barley. Even without concert of action among the farmers of a certain region, it will benefit the individual to abstain from Wheat and to grow Oats in preference in a year when bugs are expected, but concert of action is far preferable.

Early Sowing and Manuring.—From the evident fact that a strong, healthy, well-grown plant will better resist the attacks of the insect the deduction follows that Winter Wheat sown early upon well-manured ground and given careful cultivation will be farther advanced in the spring and will suffer less from the attacks of the bug. Heavy manuring will also cause a denser growth, which experience shows to be prejudicial to the bugs.

Rolling.—The female Chinch Bug in the spring seeks preferably friable ground in which to lay her eggs; consequently rolling the land in the fall after the crop of Winter Wheat is put in will render it less favor-

able to such egg laying. The same thing may be done with even better success after sowing Spring Wheat.

Sowing an unattractive Crop with Wheat.—Good results have been obtained, as shown by Professor Riley, by sowing 1 or 2 quarts of Flax to the acre in the spring among Fall Wheat. It is put in in early spring with a light harrowing and rolling. Its growth does not materially injure the crop. Flax and Barley have also been sown mixed upon the same ground, the seed being separated in cleaning. Similarly, cornfields which promised a poor stand have been harrowed and sown to Buckwheat. We have already mentioned in our section on food plants the successful experiment detailed by Professor Forbes in sowing Timothy in the fall with Winter Wheat or Rye, and the same author states that in southern Illinois the sowing of Clover in spring on Winter Wheat is largely practiced "with unquestionably good effect, provided that the clover grows freely enough to shade the ground by the time the young Chinch Bug gets fairly under way." In that latitude, however, he states that the clover often makes too slow a start to effect this purpose. Professor Riley also states that it is recommended to sow 1 bushel of Winter Rye with each 12 bushels of Spring Wheat, either for the same reason or from the idea that the bugs will prefer the younger to the older grain.

Direct Winter Remedies.

Stress should be laid upon the great necessity for concerted work in winter time.

Burning.—Professor Riley says:

> I can not lay too much stress on the importance of winter work in burning cornstalks, old boards, and all kinds of grass, weeds, rubbish, and litter around grain fields, and even the leaves in the adjoining woods, in and under all of which the little pest hibernates.

In almost every locality the insects will be found to have some particularly favored hibernating place, where they can be attacked and burned out. The locality studied by Professor Atkinson in North Carolina and mentioned in a previous paragraph is a particularly good instance. There a little careful search in the fall showed the bugs preparing to hibernate in great numbers in the Crab-grass, and nothing could be easier in the winter than to burn down every spear of this grass in the vicinity of the grain fields. In the newer parts of the West, where unbroken prairie land adjoins fields of grain, it is advisable to burn over the former early every spring. Indeed this course is an absolute necessity under such conditions.

Fall Plowing and Harrowing.—After burning, if the soil can be plowed and harrowed, the chances for successful hibernation of the bugs which escape burning will be reduced to a minimum. In the same way, without burning, late fall plowing and harrowing will do much good.

Gas Lime.—Where gas lime can be easily and cheaply obtained an application of two hundred bushels to the acre will prove valuable as a fertilizer and will destroy such hibernating insects as it may reach.

Trapping.—We quote again from Professor Riley:

Much good winter work may be done also in the way of trapping the bugs. In seeking winter quarters they show a decided partiality for any flat substance, such as old boards, that do not rest too closely upon the ground. If all old boards that can be obtained are laid around the field in the fall in such manner that the larger part of the lower surface will not quite rest on the ground—which of course it will not do if the ground is in the least uneven or covered with grass—the bugs will collect under such traps and during the cold weather of winter may be scraped from them on to dry straw and burned.

He has also suggested that shocks of corn-stalks should be made at intervals throughout the field before winter sets in so as to attract the bugs, which will congregate in the shocks, where they can be burned at leisure. Almost any inflammable rubbish could be used for this purpose. In the neighborhood of sorghum mills bagasse has been used with good effect. The piles should not be too large or too compact. They should be placed during September and should be burned in December.

Trampling.—The following paragraph is from Professor Riley:

Where the custom of allowing cattle to range during the winter in the husked corn-fields, even the few Chinch Bugs which secrete in the stalks are apt to get killed by the feeding and trampling.

Direct Summer Remedies before Migration.

As is the case with so many other destructive insects, it is not until they are under full headway and in the act of doing their greatest damage that an appeal is made to the entomologist for relief, and at such times it is usually by far the most difficult thing to give any advice. A wheat field full of Chinch Bugs is as disagreeable a sight to the economic entomologist as it is to the farmer who owns it, for nothing can be done to save it. If the hand of Providence should interpose with a long-continued drenching rain relief would be gained, but in almost no other way are the crops to be saved.

Irrigation.—It was the fact just mentioned which led Professor Riley, in his 7th Report on the Insects of Missouri, to strongly recommend irrigation where it can be practiced. He says:

Irrigation, where it can be applied, and it can be in much of the territory in the vicinity of the Rocky Mountains, where the insect commits sad havoc, and with a little effort in many regions in the heart of the Mississippi Valley, is the only really available, practicable remedy, after the bugs have commenced multiplying in the spring. I wish to lay particular stress on this matter of irrigation, believing, as I do, that it is an effectual antidote against this pest, and that by overflowing a grain field for a couple of days, or by saturating the ground for as many more in the month of May, we may effectually prevent its subsequent injuries. * * * We can not, at the critical moment, expect much aid from its natural enemies, for these are few and attack it mostly in the winter time. We must, therefore, in our warfare with this pest, depend mainly on preventive measures where irrigation is impossible.

Later (Amer. Agriculturist, Dec., 1881, also Ann. Rept. as Entomologist Dept. Agr. for 1881–'82, pages 88–89) he expressed himself even more explicitly upon this subject:

I have found no occasion to change my opinion as to the value and potency of irrigation as a remedy for Chinch-bug injuries, a remedy, too, that is within the reach of most farmers, for there are few who might not, with the aid of proper windmills, obtain the water requisite for irrigating their fields at the needed time, while many have natural irrigating facilities. I have repeatedly laid stress in my writings on the importance of irrigation in combating several of our worst insect enemies, and aside from its benefits in this direction, every recurrence of a droughty year, such as the present, in large portions of the United States, convinces me of its importance as a means of guarding against failure of crops from excessive drought. I am glad to know that many farmers, and especially small fruit-growers in the vicinity of New York, are preparing in one way or another for irrigation whenever it becomes necessary, and I was pleased to hear Dr. Hexamer, at the late meeting of the American Pomological Society, urge a general system of irrigation as the most profitable investment the cultivator can make in a climate subject to such periods of drought as ours is known to be.

Burning.—In addition to winter burning the remedy can be used to good effect in other cases. For instance where the attack of the bugs appears to be confined to a definite portion of the field, that portion should be overlaid with straw and burned, if not too large. Another pertinent suggestion is made by Dr. Thomas in Bulletin 5, *U. S. E. C.*, and this has the indorsement of practical use by certain Illinois farmers.

If it is found at the time wheat is harvested that the bugs have not taken their departure, as is the case in the winter-wheat section, this fact may be taken advantage of to destroy a very large portion of them. If the wheat is at once thrashed and the straw scattered over the stubble and burned, it will destroy all or most of those that are there. I know of one section of southern Illinois where this has been practiced for a number of years by the German farmers with good results.

This remedy is very practical and doubtless can be used to good effect under such circumstances.

The following experiments in burning were made the past season at Ames, Iowa, by Professor Osborn, and the account is taken from his manuscript report:

On July 16 the stubble adjoining a corn field was observed to contain large numbers of bugs traveling toward corn. In the afternoon this migration was going on quite actively, and as the stubble was now quite dry it was fired with a view of destroying bugs remaining in it. Where tolerably thick, and when there was a fair breeze, it burned readily, but it was necessary to take some pains in carrying the flame along past thin spots to keep it from dying out. A considerable portion of the field, however, was successfully burned over, and the dead bodies of many bugs not completely consumed, which could easily be found on examining the burnt area, testified to the destruction of hosts of the pests. The bugs thus killed were mostly young larvæ, the majority of the adults and larger larvæ and the pupæ having already moved out. The number destroyed, however, must, I think, have well repaid the little trouble necessary to burn the stubble.

Early in August the bugs had so multipled in a field of Hungarian grass that no further growth seemed probable, and most of the field was mown and the hay secured. A narrow strip, however, was left next the corn, the plan being to burn this as soon as bugs began passing to the corn. When the bugs started, however (August 13), the grass was not dry enough to burn except in spots. In such places as would burn, however, hosts of bugs were consumed. This strip was at once mown, and after drying a few hours another attempt made to burn it, as also on the following day; but portions were still too green to burn rapidly, and, unfortunately for the experiment,

the two or three days following were not hot and dry enough to render it fit to burn readily. A few days later, however, on a dry day with a fair breeze, most of the strip remaining unburnt was burned over, and examination showed that great numbers of young bugs remaining were destroyed. Bugs, if under ground or secreted in roots of stubble, will not be killed; hence to destroy greatest numbers, as well as to secure most rapid burning, the fire should be started in the hottest part of a dry day, when bugs in greatest number will be moving.

Prevention of Migration—direct Remedies during and after Migration

As has been so often pointed out, a great deal can be done in the way of destroying the insects at the time when they migrate from the wheat fields, towards the close of the first generation, to corn and other neighboring crops.

Ditching.—As long ago as Le Baron's first paper and as Fitch's second report the method of digging a ditch or plowing a furrow around the infested field was in vogue. If a plowed furrow be made the perpendicular side should be towards the field to be protected and the earth should be kept friable by dragging a log or brush occasionally through it, or, better still, a triangular weighted trough. The migrating bugs will fail to climb the side of the furrow and will fall back into it, where they can be covered with straw and burned. With care and activity the neighboring fields can be thus protected.

A modification of this plan appears in an unplaced newspaper cutting in our possession. It is as follows:

When they first appear, as they usually do, on the side of the corn field, and before they have entered it, cut five or six rows of the corn and clear the ground; then plow a strip of land 8 or 10 feet wide, leaving a deep furrow in the center of the same. Then take the corn stalks which were taken from the land, and place them across the dead furrow, and the trap is complete. When the bugs approach the field, they will pass in under the corn placed across the dead furrow, and, preferring the shade and moisture, remain there until the stalks become perfectly dry, when they can be put through a process of cremation that will prove effectual in destroying them. Should they first appear in the middle of a field of corn (as it not unfrequently happens they do), they can be surrounded on the foregoing plan and destroyed in the same way. This plan we consider the most practical of any that has come under our observation, and is corroborated to some extent by the experience of J. W. Martin, an observing farmer, whose experiments are given in the Osage Mission (Kans.) Journal.

Tarred Boards or Tar alone.—The plan has been adopted and is recommended in the reports of Professor Riley and others of using common fence boards—6 inches wide or less—setting them upon edge and making a barrier of them around the infested fields, care being taken to cover the lower edge so that the bugs will not crawl under them. The upper edge is spread with fresh tar, which is occasionally renewed. Vast numbers are taken out from holes dug at intervals on the hitherside of the barrier, in which the marching armies collect. Commenting upon this remedy Professor Riley says: "with a little care to keep the tar moist by renewal the boards may be dispensed with and the tar poured out of a kettle on to the ground; about a gallon is required to the rod, and it should be renewed every other day, oftener when rains prevail, until

the bugs are destroyed." According to Dr. Le Baron this method was extensively used in the central part of Illinois and especially in the vicinity of the Bloomington gas works in 1872. He saw the operation performed near Bloomington, where the tar was poured from an old tea-kettle on the ground along the exposed sides of a corn-field. This remedy, however, will seldom be used on account of its expense, except in such situations as that mentioned, where the tar can be readily and cheaply procured.

Sowing Strips of Plants distasteful to the Bugs around the Fields to be protected.—This remedy has been urged by certain authors, and the crops to be used as barriers are preferably Flax, Hemp, Clover, and Buckwheat. The effect of this will be to deter and destroy the migrating individuals and cause the death of the young ones by starvation. It is, however, not a thorough remedy, and is not to be compared with the more direct remedies which caused the almost complete destruction of the insect.

Sowing Strips of favored Food around the Fields to be protected.—A strip of Timothy, Hungarian grass, or Millet may be sown around the corn-field to good advantage with the object of entrapping the migrating bugs by plowing it under and burning the ground over when it has become filled with the migrating armies in transit. The bugs of the first generation, which are full grown, will lay their eggs by preference in this protective strip, and these will be destroyed by the plowing and burning.

Hot Water and Soap-suds.—The application of strong soap suds to the insects when gathered upon the outer rows of corn was recommended by a writer in the Southern Planter many years ago, and was also given by Dr. Fitch. Statement is made that a half gill or a gill poured upon each stalk will kill them all, and that the labor is not half so great as a single hoeing of the crop. Hot water has been recommended for a similar purpose by subsequent writers.

Kerosene Emulsion.—A new and, under certain circumstances, very efficacious remedy for the Chinch Bug was introduced when Professor Riley, in 1882, first suggested to Professor Forbes the advisability of experimenting with this substance upon this insect. Professor Forbes's first experiments were reported to this Division and the results were published in Bulletin No. 2 (February, 1883), pages 23 to 25. The following solutions were used in these experiments:

Solutions with which dilutions were made: (1) Soap-suds, 1 pound soap to 10 gallons water; (2) soap-suds, 1 pound soap to 20 gallons water; (3) potash, 1 pound to 50 gallons water.

EMULSIONS AS DILUTED.

	Per cent. of kerosene.
A. 2 parts kerosene, 1 part milk, 45 parts water (about)	4
B. 1 part kerosene, 1 part milk, 18 parts water	5
C. 1 part kerosene, 1 part milk, 18 parts solution 1	5
D. 1 part kerosene, 1 part milk, 38 parts solution 2	2½
E. 1 part kerosene, 1 part milk, 38 parts water	2½
F. 1 part kerosene, 1 part milk, 38 parts solution 3	2½
G. 1 part kerosene, 1 part milk, 30 parts solution 2	3

All of these were efficacious. Fortunately at the time when such application is to be made, viz, just after wheat harvest, help is abundant and the work can be done at a reasonable expense. Experiments made by Professor Forbes show that a simple mechanical mixture of one part of kerosene to three of water will kill the bugs and will not injure half-grown corn if it is kept constantly agitated. But the original soap emulsion, recommended so often in the reports of this Department and made according to the formula originally proposed by Mr. Hubbard, will be much safer and will do thorough work. It will do no harm to repeat this formula:

Kerosene	2 gallons	= 67 per cent.
Common soap, or whale-oil soap	½ pound	= 33 per cent.
Water	1 gallon	

Heat the solution of soap and add it boiling hot to the kerosene. Churn the mixture by means of a force-pump and spray-nozzle for five or ten minutes. The emulsion, if perfect, forms a cream which thickens on cooling, and should adhere without oiliness to the surface of glass. Dilute before using one part of the emulsion with nine parts of cold water. The above formula gives 3 gallons of emulsion and makes, when diluted, 30 gallons of wash.

We realize the objections to recommending anything complicated in the way of a mixture and of apparatus for applying it, and in consequence we may state, as showing that an ingenious individual who is in earnest need not be hindered by lack of a proper apparatus for applying this mixture, the experience of Maj. R. S. Tucker, of Raleigh, N. C., as published in the News and Observer, and in a special bulletin of the State Department of Agriculture, Raleigh, June 29, 1887. His letter stated in brief that having tried a number of remedies he learned of the kerosene emulsion at a time when the pest was most abundant upon the outer rows of corn. Not having any force pump or spray-nozzle with which to churn the emulsion, he whipped the mixture in a large receptacle with a bunch of twigs for ten or fifteen minutes and then applied it to his outer rows of corn with a common water-sprinkler. The results were admirable, and certainly he deserved success for his trial.

Another practical test was made by Professor Atkinson, and reported upon in the bulletin just mentioned, as follows:

Mr. William F. Stroud, of Chapel Hill, had a field of wheat which was infested with the chinch bugs. When the wheat was harvested they immediately betook themselves to the corn which was adjacent. Some of the corn stalks for 1 foot or 18 inches above ground were literally black with the mass of insects, and sometimes when they could not be seen outside they were found in great numbers between the sheath of the blade and the stalk.

[Here follows the kerosene-soap emulsion formula just given.]

I found these proportions made the liquid a little weak, and I diluted in the proportion of six parts of cold water to one of the emulsion. The application of this to

the corn, June 25, was a perfect success in killing the bugs, and the corn was examined later and was found to have sustained not the slightest injury.*

In my experiment I used a spraying apparatus, manufactured by A. H. Nixon, Dayton, Ohio, which consists of a square tank, which has a capacity of 8 gallons, with with a force-pump hose and spray-nozzle attached. This machine (called the Little Gem) was placed upon a rough sled made for the purpose, which was drawn between the rows by a mule.

As the spraying apparatus produced too wide a stream to apply the liquid rapidly and effectively to the stalks of corn, I removed the spraying portion of the nozzle and used the part which produces a very narrow but strong stream (one-sixteenth of an inch in diameter). The liquid would run down the stalks and between the sheath of the blade and stalk, killing instantly the hundreds of insects with which it came in contact. The two rows were sprayed as far as the stream would reach on each side, and then the mule moved on to stop for another application. In this way the corn was gone over very rapidly. Where a force-pump can be obtained it is better to apply it with this, but the nozzle should be very small, so as to throw a very narrow stream or spray directly against the stalk. If a force-pump can not be obtained, a common watering pot, with a narrow nozzle, could be used very effectively. Several of these could be used, the operators going quite rapidly from one stalk or hill to another.

There is no reason why all should not get rid of the chinch bug on corn, for a failure to kill the bugs would arise from some fault in the application, and the application can be made cheaper than a dressing of the corn could be made with the hoe.

This application was made late in June, and Mr. Stroud reported several times later in the season that nothing more had been seen of the bugs, and Professor Atkinson, visiting the field October 17, found no Chinch Bugs in the corn-stalks where the emulsion was used, nor in the neighboring Crab-grass. Some were found, however, about 40 rods away in some late corn, but they were few in number.

Professor Osborn's experiments with kerosene emulsions, made during the summer at our request at Ames, Iowa, are reported by him as follows:

A number of trials were made with kerosene emulsion first with a view to testing its value under various conditions, and afterward for the sake of checking the damage threatened to corn.

The first trial was made July 15, the emulsion used being the common one, consisting of kerosene, soap, and water diluted to about 5 per cent. kerosene. The bugs were killed very quickly by this application, and great numbers of them could be reached, but many in particularly secreted places, in folds of leaves and under lumps of earth, escaped. Thrown on to the leaves and running down between leaf and stalk, it dislodged and killed immense numbers. Thrown against stalks where they were congregated it would quickly dislodge the mass, and while it was impossible to see whether all driven off in this way were sufficiently wet to kill them, it was certain that most of them were. This application was at the rate of about 1 gallon of emulsion or 12 gallons of the diluted mixture to 5 rows of corn for 32 rods, or what would equal 5 gallons of emulsion, 60 gallons of diluted mixture to the acre, or a cost for material of less than 60 cents per acre. In trials of the emulsion diluted to range from 2 per cent. to 7 per cent. of kerosene, less than 4 or 5 per cent. was found to be unsatisfactory, and at the lowest figure bugs even when thoroughly drenched and kept for a time in the fluid were able to recover. A mixture (about 2 per cent., pos-

* Professor Atkinson has since written that subsequent tests convinced him that one part of the emulsion to nine of water made the mixture quite strong enough.—L. O. H.

sibly a little less) which killed plant lice almost instantly, affected chinch bugs but slightly, if at all, and they afterward recovered and lived in confinement for many days.

On August 15 applied kerosene emulsion to bugs accumulating on corn, using an emulsion diluted to contain about 6 per cent. kerosene and spraying with cyclone nozzle. Great numbers of bugs could be found dead within a few minutes after application, and on the following day hosts of dead could be found on the ground around the hills treated. In places, however, the stalks had become well covered by live bugs that had moved in to fill the place of the slain.

Subsequently the farm department applied it on a larger scale, using 5 to 6 per cent. emulsion, and spraying from barrels in a wagon, one man working the force-pump and another manipulating the hose and cyclone nozzle, walking rapidly among the hills of corn and directing the spray upon the masses of bugs. This resulted in the destruction of great numbers. In this application the cyclone nozzle was found by all means most satisfactory.

I suggested its trial to some of my correspondents, and one letter received in reply is of sufficient interest to be noted:

CAMBRIDGE, IOWA, *July* 20, 1887.

DEAR SIR: Your most satisfactory letter received some time since. The conclusion is a success; it was instant death to the chinch bugs. But it takes so much when you want to go over five or six acres that one can not stand the expense. It could be stood to go over it once or twice if I could have got the bugs all on the corn, but they would a part stay on the corn while the rest would lie under sods and anything else that would protect them from the sun. When your letter reached us they had left the wheat (which they fully destroyed), and had gone into the corn, which they killed for ten or twelve rows in some places, and some places not so far. Then they scattered over more territory for a time, but now they have left the corn (almost), having flown away, I think. I am under obligations to you for your kindness.

Very respectfully,

J. E. WARREN.

Professor OSBORN,
Ames, Iowa.

The use of kerosene can hardly be expected to prove of value except when the bugs are massing on corn. At this time, application to an acre or two of the field next to stubble may do much to save the rest of the field. By arranging nozzles with special reference to most efficient work in corn rows, and while corn is small enough to drive a team in the field astride of one row, I think spraying can be done quite thoroughly at a cost of 30 to 40 cents per acre for material.

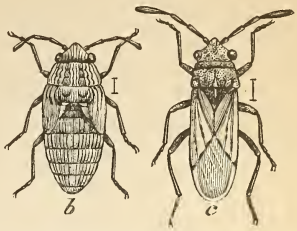
A cyclone nozzle, with pressure sufficient to do good work, discharges about 1 pint of liquid per minute. Adjusting three nozzles to play upon one row of corn, one each side, and one from above, and allowing teams to walk slowly 2 miles per hour, and it will take 30 gallons of liquid per acre, which, using 5 to 6 per cent. emulsion, costs about 30 cents, exclusive of labor, which for team and man an hour and a quarter would be about 40 cents more. First cost of force pump must, of course, be considered; the cost of labor on the farm, however, where the farmer uses his own team and does the managing of apparatus himself, might be counted less. By using only two nozzles or by driving faster the expense will be lessened.

BOGUS CHINCH BUGS.

Professor Riley figures and describes in his Seventh Report on the Insects of Missouri four species of Heteroptera which are frequently mistaken for the Chinch Bug and are often the cause of unnecessary alarm. We here reproduce the figures of these species. The first is the False Chinch Bug (*Nysius augustatus* Uhl., Fig. 8), which was frequently sent

to Professor Riley. It is found all over the country and occasionally damages certain crops quite seriously—grapevines, strawberries, potatoes, young apple grafts, and all cruciferous plants. It is also very fond of Purslane and, as mentioned elsewhere in this report, it is found in California congregating under *Polygonum*. It is the insect which caused the alarm in California in 1885. It was originally described by Uhler under the name above given, but was subsequently redescribed by Mr. William R. Howard as *Nysius raphani* and by Professor Riley as *Nysius destructor*. Professor Riley's description was, however, drawn up with Mr. Uhler's sanction, as the latter author at that time considered that the form described by Professor Riley might be distinct.

[Fig. 8.]



FALSE CHINCH BUG:—*b*, pupa; *c*, mature bug. [After Riley.]

The Insidious Flower-bug (*Triphleps insidiosus* Say, Fig. 6) is another of these bogus Chinch Bugs. It is also a very wide-spread insect, and so far from being injurious it is one of the comparatively few insects which prey upon the Chinch Bug.

The Ash-gray Leaf-bug (*Piesma cinerea* Say, Fig. 9) is another wide-spread species which occasionally damages grape blossoms in early spring, but lives principally upon forest trees and shrubs. This species is also often mistaken for our insect.

[Fig. 9.]

ASH-GRAY LEAF-BUG. [After Riley.]

The Flea-like Negro-bug (*Corimelæna pulicaria* Germ., Fig. 10) is the fourth.

Its appearance is more different from the Chinch Bug than any of the insects mentioned under this head, as is plainly shown by the figure. It feeds abundantly upon the fruit of the Raspberry and punctures also the stem of the Strawberry and the blossoms, leaves, and fruit-stems of the Cherry and Quince. It is also injurious to certain garden flowers and to certain weeds, among which Professor Riley mentions *Ceanothus americanus* and *Veronica peregrina*.

[Fig. 10.]

FLEA-LIKE NEGRO-BUG. [After Riley.]

We may mention under this head the rather curious fact that the Striped Flea-beetle—*Systena elongata* Fab.—was found the past season in great abundance in company with Chinch Bugs in fields infested by the latter in Nebraska by Mr. Bruner. They appeared to be working upon grass and upon the wild Buckwheat. Their appearance accompanying the Chinch Bug had, of course, no especial significance, but at the same time occurring in such a way they were liable to be mistaken for another form of the Chinch Bug.

BIBLIOGRAPHICAL LIST.

[This is simply a list of the more important of the Chinch-bug articles. No mention is made of a very large number which we have seen, but which contain nothing new or original. Every progressive step of knowledge is mentioned in some one of the articles here mentioned.]

1831. Say, Thomas. *Lygæus leucopterus.* Descriptions of new species of Heteropterous Hemiptera of North America, New Harmony, Ind., Dec. 1831. Complete writings. Ed. by LeConte, Vol. I, p. 329.

(Original description; described from a single specimen taken in Virginia.)

1845. Prairie Farmer, V., 227.

(Injuries in Hancock County, Illinois.)

Prairie Farmer, V., 287. Chinch Bugs.

(Injuries in Tazewell County, Illinois. An account of their season's history.)

1846. Prairie Farmer, VI., 134. The Chinch Bug.

(Injuries in Sangamon County, Illinois.)

Prairie Farmer, VI., 245. Chinch Bugs.

(Injuries in Cass County, Illinois.)

1850. Le Baron, Wm. *Rhyparochromus devastator.* Prairie Farmer, Vol. X, p. 200.

(Described imago, and proposes specific name *devastator;* mentions that eggs are deposited on roots; points out its destructive characters as an insect enemy.)

1851. Prairie Farmer, XI., 335. The Chinch Bug.

(Distribution within the State of Illinois.)

1852. Harris, T. W. *Rhyparochromus leucopterus.* Treatise on insects of Massachusetts.

(Describes briefly imago; speaks of distribution and injuries. Records finding in his garden in 1852.)

1855. Fitch, Asa. *Micropus leucopterus.* The Cultivator, 3d series, III, 237–239.

(Correspondent writes from Indiana. Fitch gives account of habits and injuries, past history, and nomenclature.)

1856. Fitch, Asa. *Micropus leucopterus.* Second Rep. Ins. N. Y., pp. 227–297, Plate IV, figs. 2 and 2a.

(Gives 1783 as date when first known as insect depredator on wheat in North Carolina. Notes its occurrence at several times during next fifty years in such numbers as to nearly destroy the wheat crop. Farmers ceased to plant wheat for a couple of years as only known remedy. Alludes to drought which prevailed during period of injury, and their destruction by wet weather, 1840. First attracted attention in Western States, 1840–'44. Describes young larvæ. Mentions briefly a number of varieties. Gives history of nomenclature. Suggests spraying infested fields with water as a practical remedy.)

1857. Signoret, V. *Micropus leucopterus* Say. Essai monographique du Genre Micropus, Spinola, Ann. Soc. Ent. de France, V, 3d series, p. 31.

(A technical description from specimens received from New York and Cuba.)

1861. Walsh, B. D. Chinch Bug. Insects injurious to Vegetation in Illinois. Trans. Ill. State Agr. Soc., Vol. 4, 1859–'60, pp. 346–349.

(First notice of four Ladybird enemies of the Chinch Bug. Figures Hipp. maculata, and Coccinella munda.)

1862. Harris, T. W. *Rhyparochromus leucopterus.* Insects injurious to Vegetation, 3d ed., pp. 197–200, fig. 84. (See under 1852.)

1865. Riley, C. V. The Chinch Bug. Prairie Farmer, September 19, 1865.

(Exposes the fallacy of a reported observation by Mr. D. H. Sherman in the Waukegan Gazette, to the effect that the eggs are laid upon the wheat-head.)

1866. WALSH, B. D. Chinch Bugs. Practical Entomologist, Vol. I, p. 95.

(Prints a clipping from Prairie Farmer, stating that the "bugs" had been successfully fenced out of a field by putting boards on edge around it and coating upper edge with coal-tar.)

1866. WALSH, B. D. *Micropus* (*Lygæus*) *leucopterus*. Pract. Ent., Vol. II, p. 21.

(Notices specimens of short-winged variety from Canada.)

1866. RILEY, C. V. Chinch Bug. Pract. Ent., Vol. I, No. 6, p. 47.

(Exposes fallacy of a current theory that the eggs are deposited on the grain, and fields become infested from its use. Gives methods of depositing eggs and states that there are two generations in northern Illinois, and possibly three in more southern latitudes.)

1866. RILEY, C. V. The Chinch Bug. Prairie Farmer, Mar. 3, 1866.

(Devoted principally to remedies, recommending ditching, winter work, mixing rye or tame grass with spring wheat.)

1867. SHIMER, HENRY. *Micropus* (*Lygæus*) *leucopterus*. Proc. Acad. Nat. Sci. Phila., Vol. XIX, pp. 75–80.

(Full journal account of observations during 1864–'65 in Illinois. Conclusions as to causes of their destruction in 1865.) Page 234. (Reference to epidemic.)

1869. WALSH & RILEY. *Micropus leucopterus*. Am. Ent., Vol. I, pp. 169–177, fig. 122.

(Popular inferences, past history, natural history, checks to multiplication; review of Dr. Shimer's prophecies about appearance.)

IBID., pp. 194–199, figs. 138, 139.

(Predaceous foes of, damage done by, remedies for; summary of conclusions: (1) they hibernate in imago stage in rubbish, which should be burned; (2) early sowing in spring is an advantage; (3) compacting the soil acts as preventive; (4) heavy rains always injure or entirely destroy them.)

1869. PACKARD, A. S., Jr. *Blissus leucopterus*. Guide to the Study of Insects, pp. 543, 544, fig. 547.

(Describes imago, life history, injuries of; epidemic diseases of 1865. Cites its occurrence in Maine and at summit of Mount Washington. Notices the theory that wet weather during breeding season is destructive to them.)

1870. RILEY, C. V. *Micropus leucopterus*. 2d Rep. State Ent. Mo., pp. 15–37, figs. 1 and 2.

(An extended account and the best yet published; discusses past history, natural history, destructive powers, heavy rains, natural enemies, amount of damage, remedies, and bogus Chinch Bugs.)

1871. GLOVER, TOWNEND. *Rhyparochromus* (*Micropus*) *leucopterus*. Rep. Com. Agr., 1870, p. 89.

(Refers to observations of others as to deposition of eggs, etc.)

1872. BETHUNE, C. J. S. *Micropus leucopterus*. Rep. Ent. Soc. Ont., 1871, p. 55.

(Refers to accounts of early history, habits, enemies of, natural remedies, etc.)

1872. LE BARON, WILLIAM. *Micropus leucopterus*. 2d Rep. St. Ent. Ill., 1871, pp. 142–156.

(Estimates loss from depredations current year in Illinois ten and one-half millions dollars; treats of their prevention and destruction under five heads: (1) natural enemies, (2) early sowing, (3) preventing migrations, (4) destroying by burning rubbish, (5) cease cultivating the affected crops.)

1872. GLOVER, TOWNEND. *Rhyparochromus leucopterus*. Rep. Com. Agr., 1871, p. 84.

(Merely refers to its injuries in Western States and mentions salt being used as a remedy.)

1872. LE BARON, WILLIAM. Chinch Bug. Experience of 1872. Prairie Farmer, August 24.

(Believes that a sufficient number of these insects hibernate under dead leaves in the woods to perpetuate the species; also that the wet spring of 1872 destroyed large numbers of the Chinch Bugs.)

1874. Glover, Townend. *Micropus (Rhyparochromus) leucopterus.* Rep. U. S. Com. Agr. 1872, p. 121.

(Mentions injuries in Western States to Corn, Wheat, Sorghum, etc.; three broods reported observed in Missouri.)

1874. Johnson, B. F. Chinch Bug. Country Gent., Vol. XXXIX, p. 661.

(Abundant in central Illinois. Stock was poisoned by eating fodder. Suggests sowing plats of noxious plants, Tobacco, Night-shade, Henbane, Stramonium, Hemp etc., to assist in checking their ravages.)

1875. Glover, Townend. *Micropus (Rhyparochromus) leucopterus.* Rep. Com. Agr., 1874, pp. 127, 128.

(Gives localities in Southern and Western States where reported as injurious.)

1875. Riley, C. V. *Micropus leucopterus.* 7th Rep. State Ent. Mo., pp. 19–50; appendix, pp. 51–71, figs. 2, 3, and 4.

(Résumé of previous history, *full descriptions of various stages*, natural history, extended account of injuries in 1874, exhaustive discussion of preventive measures and remedies, mentions irrigation, predaceous enemies. Appendix, correspondence of farmers relating to 1874 damage.)

1875. Riley, C. V. Locusts *vs.* Chinch Bugs. N. Y. Weekly Tribune, August 4, 1875.

(A letter from Lyons, France, remarking upon the abundance of Chinch Bugs and allaying fears as to great destruction by them.)

1876. Uhler, P. R. *Blissus leucopterus.* List of Hemiptera of the region west of the Mississippi River, including those collected during the Hayden explorations of 1873. Bulletin U. S. Geol. and Geog. Sur. Terr., I, second series, No. 2, p. 306.

(Mere mention, with a list of localities.)

1877. Packard, A. S., Jr. *Blissus leucopterus.* 9th Rep. Geol. and Geog. Sur. Terr., 1875, pp. 697–699, fig. 4 and map.

(Refers to its destructiveness in the Western States, quotes estimates of different State Entomologists, notices briefly some of the remedies.)

1878. Thomas, Cyrus. *Blissus leucopterus.* 7th Rep. State Ent. Ill., pp. 40–71, 2 figs.

(Résumé of history, natural history, descriptions, etc. Two brooded in northern Illinois, possibly three in southern Illinois. Remedies and general discussion of same).

1879. Riley, C. V. Entomological Notes. The Chinch Bug. Farmers' Review (Chicago), February, 1879.

(Discusses weather influence and advances parallel between Rocky Mountain Locust and Chinch Bug. Review of life history and summary of facts from Seventh Rept. Ins. Mo. Prediction of bugs in 1879 if weather prove dry.)

1879. Thomas, Cyrus. *Blissus leucopterus.* Bull. U. S. Ent. Com. No. 5. Ten figures, map showing distribution.

(Exhaustive résumé of present knowledge with facts concerning injuries, natural history, predaceous enemies, full discussion of preventive and remedial measures.)

1880. Kansas State Board of Agriculture. Quarterly Report for the quarter ending June 30, 1880, Topeka, July 20, p. 61.

(An account of damage to Sorghum.)

1880. Thomas, Cyrus. Temperature and Rainfall as affecting the Chinch Bug. Am. Ent. New series. Vol. I, pp. 240–242, with diagram.

(Condensation of his theory about periodicity of seasons of drought and their relation to appearance of this insect.)

1881. Thomas, Cyrus. The Relation of Meteorological Conditions to Insect Development. 10th Rep. State Ent. Ill., pp. 47–59, with diagram.

(Discusses theory of Septenary Cycles of Meteorological conditions; believes it possible to predict with considerable certainty the season when Chinch Bugs will appear in injurious numbers.)

1881. Riley, C. V. Am. Nat., October, p. 820.

(Calls attention to the verification of Prof. Cyrus Thomas's prediction that this would be a bad Chinch-Bug year.)

1881. RILEY, C. V. Am. Agriculturist, Nov. and Dec., 1881.

(Reviews natural history and remedies, and discusses the practicability of irrigation as a remedy.)

1882. HOWARD, L. O. Rep. U. S. Dept. Agr., 1881–'82, p. 137.

(Mentions it as infesting Rice affected by "white blast.")

1882. RILEY, C. V. Chinch Bug Notes. Rept. Ent., Ann. Rept. U. S. Dept. Agr., 1881–'82, pp. 87–89.

(Calls attention to Professor Thomas's prediction of injury during 1881 and the fact that it was partially fulfilled; discusses briefly remedies and methods of prevention.)

1882. FORBES, S. A. *Bacterium.* A parasite of the Chinch Bug. Am. Nat. Vol. XVI, p. 824.

(Account of discovery of parasitic disease among Chinch Bugs.)

1882. FORBES, S. A. *Blissus leucopterus.* 12th Rep. State Ent. Ill., pp. 32–63, fig. 6.

(Gives full account of observations on life history, etc., for the year, insect enemies, a new insect enemy, bird enemies, account of observation on a bacterium parasite. Experiments in drenching with water under artificial conditions (not fully carried out), report of experiments with topical applications.)

1882. RILEY, C. V. The Chinch Bug. Am. Agriculturist, p. 476, 3 figs.

(General account of, habits and natural history, meteorological conditions affecting.)

1883. LINTNER, J. A. Cir. No. 1, N. Y. St. Mus. Nat. Hist.

(Directions for arresting Chinch Bug invasion of northern New York.)

1883. LINTNER, J. A. The Chinch Bug in New York. Country Gent., Nov. 8, 1883.

(Directions for co-operation among farmers to prevent ravages coming year.)

1883. FORBES, S. A. Experiments on Chinch Bug. U. S. Dept. Agr., Div. Ent., Bull. No. 2.

Memoranda of experiments with kerosene emulsion and mixtures, made at the suggestion of Professor Riley; found them quite effective.

1883. FORBES, S. A. Entomological Notes of the Season. State Dept. Agr., Cir. 106, Ill., crops for 1883, p. 177.

(Notes the deposition of eggs for first brood on the roots of Indian Corn.)

1883. SAUNDERS, WM. *Micropus leucopterus.* Rep. Ent. Soc. Ont., pp. 59–62.

(Account of appearance in New York; quotes from Lintner.)

1883. RILEY, C. V. Chinch Bug in New York. Science, Vol. II, 1883, p. 621.

(Cites facts to show that their appearance in New York is not an invasion, but extraordinary development of the species, dependent upon climatic conditions.)

1884. RILEY, C. V. The Chinch Bug in New York State. American Naturalist, Jan., 1884, Vol. XVIII, p. 79–80.

(A reprint of an unplaced article in Scientific American criticising Dr. Lintner's conclusions as to reasons for alarm in northern New York.)

1884. LINTNER, J. A. 37th Ann. Rep. N. Y. St. Mus. Nat. Hist., pp. 53–60.

(Not seen.)

1885. BRUNER, LAWRENCE. *Blissus leucopterus.* Rept. Ent., Ann. Rept. Dept. Agr., 1884, p. 399.

(Cites an instance where large numbers disappeared immediately after a heavy rain.)

1885. RILEY, C. V. Chinch Bug Notes. Rept. Ent., Ann. Rept. Dept. Agr., 1884, pp. 403–405.

(Refers to occurrence in New York and considers that there is no cause for alarm; predicts they will attract no further notice.)

1885. FORBES, S. A. Ent. Calendar. 14th Rep. St. Ent., Ill., pp. 4–5.

(Notes on life history for year 1884.)

1885. LINTNER, J. A. *Blissus leucopterus.* 2nd Rept. State Ent., N. Y., pp. 148–164; figs. 37–38, 39 and 40.

(Account of its occurrence in northern New York, résumé of its history, life history, remedial measures employed and recommended.)

1886. HUNT, THOMAS F. *Blissus leucopterus.* Bibliography of insects injurious to corn. Misc. Essays on Economic Ent., Ill. St. Bd. Agr., 1885.

1886. WEBSTER, F. M. *Blissus leucopterus.* Insects affecting Fall Wheat. Rept. of Ent., Ann. Rept. Dept. Agr. 1885, p. 318.

(A brief record of Chinch Bug observations during the season. Records Mermis as a possible parasite.)

1886. FORBES, S. A. Chinch Bug in Illinois. Circular of information from the office of State Entomologist.

1887. BRUNER, LAWRENCE. Notes of the season. Bull. No. 13, Div. Ent., U. S. Dept. Agr., pp. 34, 35.

(Brief notices of their appearance in Western States in 1886.)

1887. FORBES, S. A. The present condition and prospects of the Chinch Bug in Illinois for 1887–'88. Bull. No. 2 of the State Entomologist.

(Speaks of ravages for three years past, life history, food-plants, preventive remedial measures exhaustively discussed.)